

SCIENCE-X

MODULE -2

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METALS AND NON-METALS

INTRODUCTION

All the materials around us are made up of chemical elements, which are found in the earth crust. Earth is the source of coal, petroleum, graphite, diamond and many other minerals of metals and non-metals. We get various useful things like gasoline, kerosene, wax, coal gas and natural gas from the natural resources, which are made up of many non-metals. These elements occur as minerals and rocks in the earth's crust. Some of these elements like oxygen, nitrogen and carbondioxide occur in atmospheric air. There are more than 115 elements known at present 80% of these elements are metals and rest are non-metals.

On the basis of their properties , all the elements can be divided into two main groups: metals and non-metals.

METALS

Metals are the elements that conduct heat and electricity and are malleable and ductile. Some of the examples of metals are : Iron, Aluminium, Copper, Silver, Gold, Platinum, Zinc.

Metals are the elements which form positive ions by losing electrons (or donating electrons). Metals are known as electropositive elements because they can form positive ions by losing electrons.

The most abundant metal in the earth's crust is aluminium.

NON-METALS

Non-metals are the elements that does notconduct heat and electricity and are neither malleable nor ductile. They are brittle. Some of the examples of non-metals are : Carbon, Sulphur, Phosphorus, Silicon, Hydrogen, Oxygen, Nitrogen. The two allotropic forms of carbon element, diamond and graphite are also non - metal.

Non-metals are the elements which form negative ions by gaining electons. Non-metals are known as electronegative elements because they can form negative ions by gaining electrons.

Carbon is one of the most important non-metals, as life on this earth is based on carbon compound because the carbon compounds like proteins, fats, carbohydrates, vitamins and enzymes etc. are essential for the growth and development of living organisms.

The most abundant non-metal in the earth's crust is oxygen.

◆ **POSITION OF METALS AND NON-METALS IN THE PERIODIC TABLE**

- (i) The elements which are placed on the left hand side (except hydrogen) and in the centre of the periodic table are called metals. Such as sodium, potassium, magnesium, calcium, iron, copper zinc etc.
- (ii) The elements which are placed on the right hand side of the periodic table are called non-metals such as oxygen, nitrogen, chlorine, fluorine etc. These metals and non-metals are separated from each other in the periodic table by a zig-zag line. The elements placed in the zig-zag line show some properties of metals and some properties of non-metals are called metalloids. Such as boron(B), silicon(Si), germanium(Ge), arsenic(As), antimony(Sb), tellurium(Te) and polonium(Po).
- (iii) The position of metals, non-metals and metalloids are shown in a simple form in figure..
Metals present at the extreme left are known as light metals, while those are present in the centre of the periodic table are called heavy metals or transition metals.
- (iv) The elements at the extreme left of the periodic table are most metallic and those on the right are least metallic or non-metallic.
Thus, metallic character decreases on going from left to right side in the periodic table. For example, sodium is more metallic than aluminium because sodium is on the left hand side of aluminium.
- (v) However on going down in a group the metallic character increases. For example, carbon is non-metal while lead is metal because metallic character increases down in a group.



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TIUPAC designations of groups of elements are given in brackets

◆ ELECTRONIC VIEW OF METAL

An element is called metal, which forms positive ions (or cations) by losing electron.

Example : Sodium is a metal which forms sodium ion (Na^+) by losing one electron.

Similarly, magnesium metal forms Mg^{2+} by losing two electrons, Al metal forms Al^{3+} by losing three electrons.

Thus, metals are also known as electropositive elements.

The atoms of metals have 1 to 3 electrons in their outermost shell. For example, all the alkali metals have one electron in their outermost shell. (Lithium-2, 1, sodium 2, 8, 1, potassium-2, 8, 8, 1, ... etc). Sodium 11(2, 8, 1) magnesium 12 (2, 8, 2) and aluminium 13 (2, 8, 3) are metals having 1, 2 and 3 electrons respectively in their outermost shell, which lose these electron easily. The number of electrons lost by an atom of a metal is called its valency.

Thus metals have 1 to 3 electrons in their valence shell of their atoms.

Exceptions : Hydrogen and Helium. Hydrogen is a non-metal having 1 electron in its outermost shell of its atom. Helium having 2 electrons in its outermost shell of its atom.

PROPERTIES OF METALS**◆ PHYSICAL PROPERTIES OF METALS :****1. Metals are malleable, i.e. metals can be beaten into thin sheets with hammer (without breaking)**

Malleability is an important property of metals. Gold and Silver metals are some of the best malleable metals. Aluminium foils are used for packing food items like biscuits, chocolates, medicines, cigarettes, etc.

ACTIVITY - 1

Aim: To test that metals are malleable, i.e. can be hammered into sheets.

Method:

- (i) Take piece of iron, zinc, lead and copper.
- (ii) Place any one metal on the block of iron and strike it four or five times with a hammer.
- (iii) Repeat with other metals.
- (iv) Record the change in shape of these metals.

Discussion and conclusion

It is observed that metals can be beaten into thin sheets, i.e., they are malleable.

2. Metals are ductile, that is, metals can be drawn (or stretched) into thin wires.

Ductility is another important property of metals. Gold is the most ductile metal. For example, 1 gram of gold can be drawn into a thin wire about 2 kilometer long. Copper and aluminium metals are also very ductile and can be drawn into thin copper wires and aluminium wires.

ACTIVITY - 2

Aim: To justify that metals are ductile, i.e., can be drawn into wire.

Method:

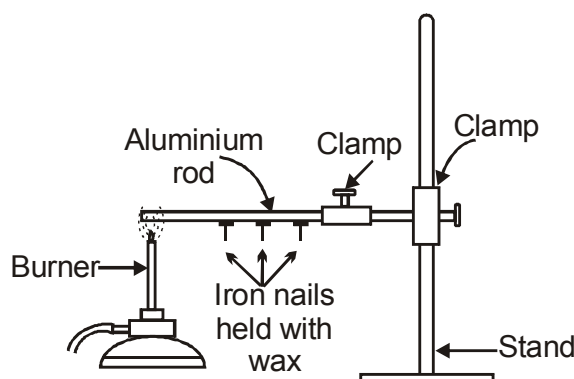
- (i) Consider some metals such as iron, copper, aluminium, lead etc.
- (ii) Check which of these metals are available in the form of wire.

Discussion and conclusion

As wires of iron, copper and aluminium are easily available, this shows that metals can be drawn into wires i.e., they are ductile.



3. Metals are good conductors of heat.



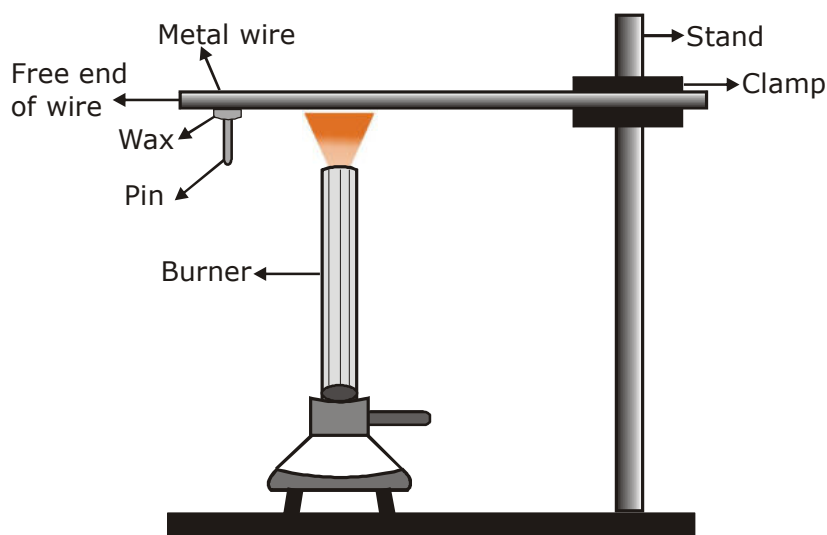
Metals allow heat to pass through them easily. Take a flat aluminium rod and stick some nails upon the rod with the help of wax. Start heating the free end of the aluminium rod by keeping a burner below it. We will see that the iron nails attached to aluminium rod with wax start falling one by one because heat travels from the left side to the right side along the aluminium rod. It melts the wax which holds the nails. Silver metal is the best conductor of heat. The cooking utensils and water boilers, etc., are usually made up of copper or aluminium metals because they are very good conductors of heat. Heat conductivity is an important property of metals.

ACTIVITY - 3

Aim: To test that metals are good conductors of heat and have high melting point.

Method:

- (i) Take an aluminium or copper wire. Clamp the wire on a stand.
- (ii) Fix a pin to the free end of the wire using wax.
- (iii) Heat the wire with a spirit lamp, candle or a burner near the place where it is clamped.



Metals conduct heat very easily

Now answer

- (i) What do you observe after some time?
- (ii) Does the metal wire melt?

Discussion and conclusion

We observe that on heating the wire near the clamp, after some time the pin falls down. This shows that heat flows through the wire and melts the wax. Further, the wire does not melt even after heating for a long time. This shows that metals have high melting points.



4. Metals are good conductors of electricity

Metals allow electricity (or electric current) to pass through them easily. Silver metal is the best conductor of electricity. The electric wires are made of copper and aluminium metals because they are very good conductors of electricity.

ACTIVITY - 4

Aim: To test that metals are good conductor of electricity.

Method:

(i) Set up an electric circuit as shown in figure.

(iii) Place the metal to be tested in the circuit between terminals A and B as shown in the figure.

Now Answer

Does the bulb glow? What does this indicate ?

Discussion

The bulb glows. This shows that electric current flows through the metal.

Conclusion

Metals are good conductor of electricity.

5. Metals are lustrous (or shiny) and can be polished

Metals are lustrous, they have a shining surface. **For example** gold, silver and copper are shiny metals and they can be polished. The property of a metal having a shining surface is called '**metallic lustre**'.

The metals lose their shine or brightness by keeping in air for a long time and acquire a dull appearance due to the formation of a thin layer of oxide, carbonate or sulphide on their surface (by the slow action of the various gases present in air).

ACTIVITY - 5

Aim : To check that metals have lustre, i.e., a shining surface.

Method:

(i) Take samples of iron, copper, aluminium and magnesium. Note the appearance of each sample.

(ii) Clean the surface of each sample by rubbing them with sand paper and note their appearance again.

Discussion: The surface of the metals is dull because they are covered with a layer of oxide, hydroxide, carbonate etc. due to the attack of gases present in the air on their surface. On rubbing the surface with sand paper this layer is removed and a shining surface appears.

Conclusion: Metals in the pure state (or freshly prepared or cut) have shining surface.

Q. Why do metals possess lustre?

Explanation

When light falls on the surface of a metal, the atoms absorb photons as energy. They get excited and start vibrating. These vibrating electrons release energy in the form of light. Therefore, metal surface shines and metals possess lustre.

6. Metals are generally hard (except sodium and potassium which are soft metals).

Most of the metals like iron, copper, aluminium, etc. are very hard. Some exceptions Sodium and potassium are soft metals which can be easily cut with a knife.

ACTIVITY - 6

Aim: To test that metals are hard and hardness varies from metal to metal.

Method:

(i) Take small piece of iron, copper, aluminium and magnesium. Try to cut these metals with a sharp knife.

(ii) Hold a piece of sodium metal with a pair of tongs.

Caution: Always handle sodium metal with care. Dry it by pressing between the folds of a filter paper. Put it on a watch glass and try to cut it with a knife.

Discussion and conclusion

All the four metals (Fe, Cu, Al and Mg) are found to be cut with difficulty. This shows that metals are hard. The ease of cutting is found to be in the order $Mg > Al > Cu > Fe$. This shows that hardness varies from metal to metal. Sodium can be cut very easily. Hence sodium is soft, i.e., it is an exception.



7. Metals are strong (except sodium and potassium metals which are not strong).

They can hold large weights without snapping (without breaking). **For example** iron metal (in the form of steel) is very strong. Due to this iron metal is used in the construction of bridges, buildings, railway lines, machines, vehicles and chains etc.

8. Metals are solid at room temperature (except mercury which is a liquid metal).
9. Metals have high melting points and boiling points (except sodium and potassium metals which have low melting and boiling points)

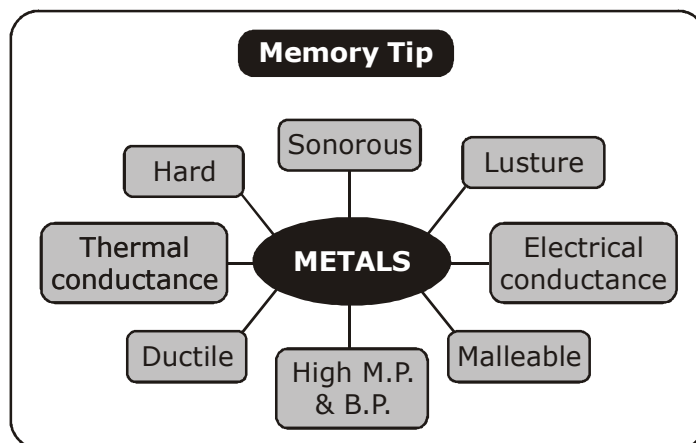
Example, iron metal has a high melting point of 1535°C . Copper metal has also a high melting point of 1083°C . Sodium and potassium metals have low melting points (of 98°C and 64°C respectively).

10. Metals have high densities (except sodium and potassium metals which have low densities)

The density of iron is 7.8 g/cm^3 which is quite high. Sodium and potassium metals have low densities (of 0.97 g/cm^3 and 0.86 g/cm^3 respectively)

11. Metals are sonorous. That is metals make sound when hit with an object.

The property of metals of being sonorous is called **sonorousness or sonority**. It is due to the property of sonorousness (or sonority) that metals are used for making bells and strings (wires) of musical instruments like sitar and violin.

12. Metals usually have a silver or grey colour (except copper and gold)

DO YOU KNOW ?


Anodising is a process of forming a thick oxide layer of aluminium. Aluminium develops a thin oxide layer when it is exposed to air. This oxide coat of aluminium (Al) makes its resistance to further corrosion. During anodising, the resistance can be improved further by making the oxide layer thicker. In this process, a clean Al article is made the anode and dilute sulphuric acid (H_2SO_4) is used for electrolyte. The oxygen gas evolved at the anode reacts with Al to make a thicker protective oxide layer. This oxide layer can be dyed easily to give Al articles an attractive finishing.

USES OF SOME METALS

- (i) Many metals and their compounds are useful in our daily life. These are as follows : Aluminium is used to prepare utensils and household equipments like vacuum cleaner. Aluminium is extensively used in making bodies of rail, cars, automobiles, trucks and aircraft. Aluminium wires are widely used in electrical work. Aluminium foil is used to wrap chocolate cigarette and medicines and to seal milk bottles.

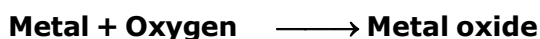


- (ii) Major use of copper is in making electrical wires & cables. Copper is also used in making utensils, steam pipes, coin and in electroplating.
- (iii) Steel is an alloy of iron which is used for making parts of machines, as building material and in the construction of refrigerator. As a matter of fact steel is said to be the back bone of industry.
- (iv) Gold and silver called noble metals (or coinage metals) are used in jewellery.
- (v) Mercury is used in thermometers barometers and to prepare amalgams.
- (vi) Platinum is used to make crucibles and electrodes.
- (vii) Zinc is used to galvanize iron, to prepare roofing material, container of dry cells and to make brass when mixed with copper.
- (viii) Metal like sodium, titanium and zirconium find their applications in atomic energy, research and medical industry.
- (ix) Titanium (Ti) and its alloys are used in aerospace, marine equipments, aircraft frames, chemical industries and chemical reactors. The wide application of titanium is attributed to its resistance to corrosion, high melting points and high strength.

◆ **CHEMICAL PROPERTIES OF METALS :**

1. Reaction of Metals with oxygen (Air)

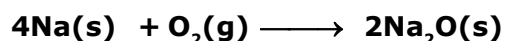
When metals are burnt in air, they react with the oxygen of air to form metal oxides :



From air (Basic oxide)

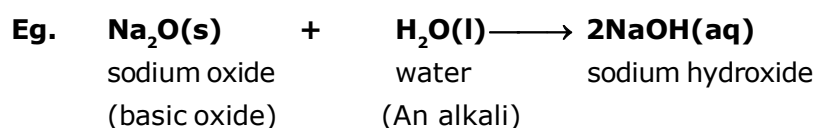
Metals react with oxygen to form metal oxides. Metal oxides are basic in nature. The vigour of reaction with oxygen depends on the chemical reactivity of metal.

- (i) Sodium metal reacts with the oxygen at room temperature to form a basic oxide called sodium oxide:

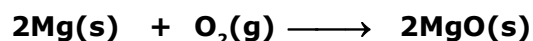


sodium oxygen sodium oxide
(Metal) (from air) (Basic oxide)

Potassium metal and sodium metal are stored under kerosene oil to prevent their reaction with the oxygen, moisture and carbon dioxide. Some of the metal oxides dissolve in water to form alkalies.

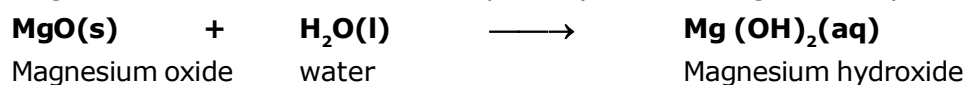


- (ii) Magnesium metal does not react with oxygen at room temperature. But on heating, magnesium metal burns in air giving intense heat and light to form a basic oxide called magnesium oxide (which is a white powder)

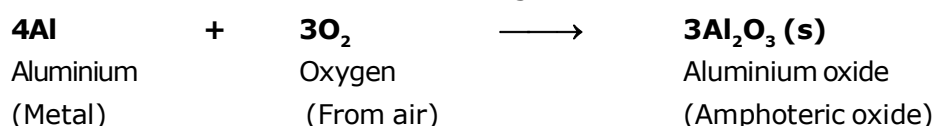


Magnesium Oxygen Magnesium oxide
(Metal) (From air) (Basic oxide)

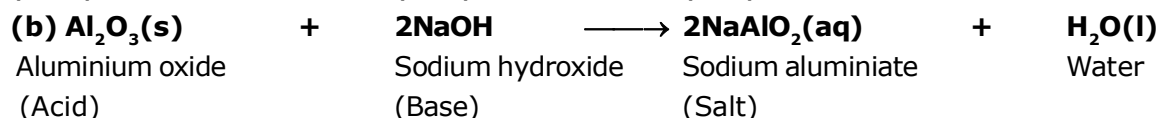
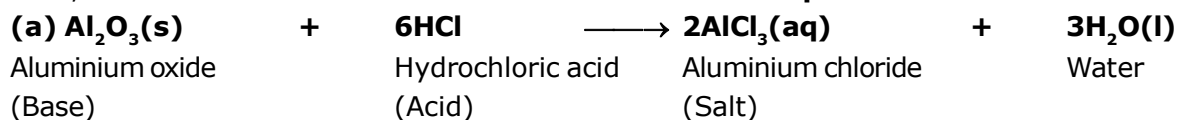
Magnesium oxide dissolves in water partially to form magnesium hydroxide solution :



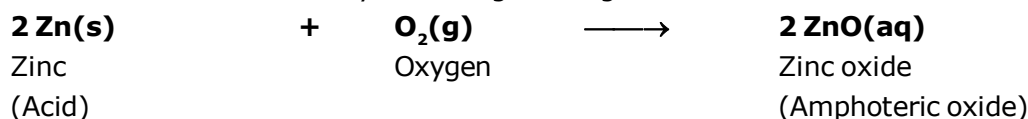
- (iii) Aluminium metal burns in air on heating to form aluminium oxide :



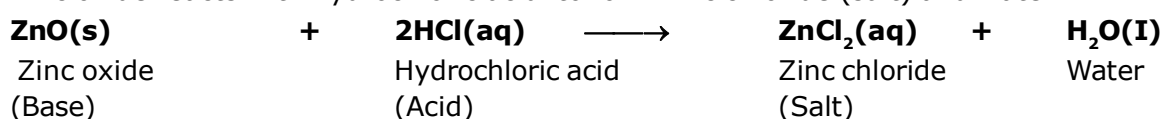
Those metal oxides which show basic as well as acidic behaviour are known as amphoteric oxides. Aluminium metal and zinc metal form amphoteric oxides. Amphoteric oxides react with both, acids as well as bases to form salts and water. **Example :**



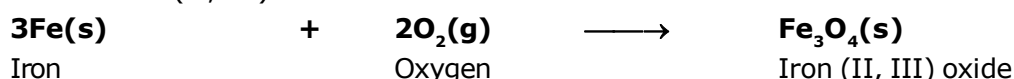
(iv) Zinc metal burns in air only on strong heating to form zinc oxide :



Zinc oxide reacts with hydrochloric acid to form zinc chloride (salt) and water.



(v*) Iron metal does not burn in air even on strong heating. Iron reacts with the oxygen on heating to form iron (II, III) oxide :



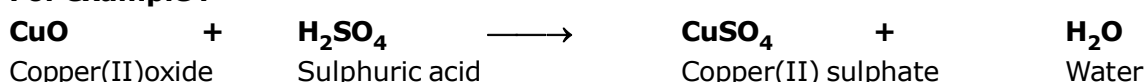
(vi*) Copper metal also does not burn in air even on strong heating. Copper reacts with the oxygen on prolonged heating to form a black substance copper (II) oxide :



◆ NATURE OF METALLIC OXIDE

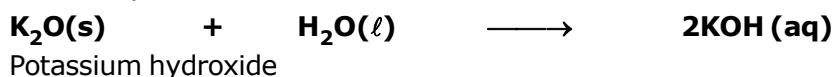
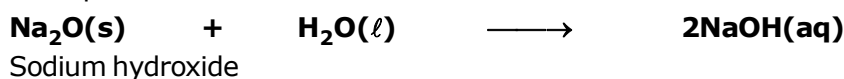
Generally, metallic oxides are basic in nature except aluminium and zinc oxides which are amphoteric in nature. This means these oxides (Al_2O_3 , ZnO) react with base as well as acid. The basic oxide of metals react with acid to give salt.

For example :

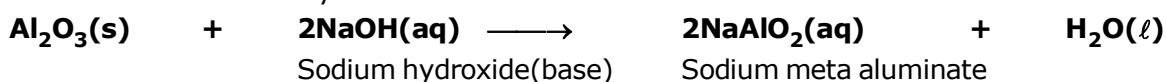
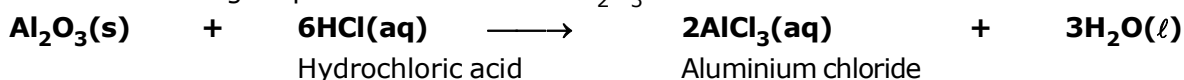


Some oxide of metals dissolve in water and form alkalis.

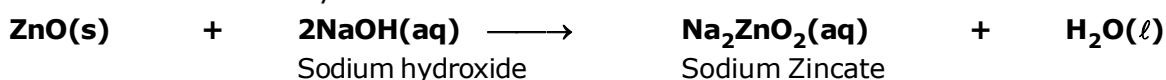
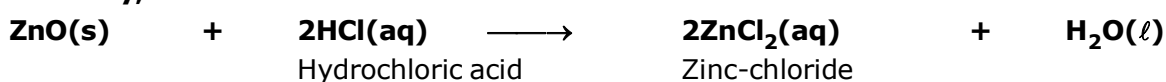
Example for :



Reaction showing amphoteric in nature of Al_2O_3 and ZnO .

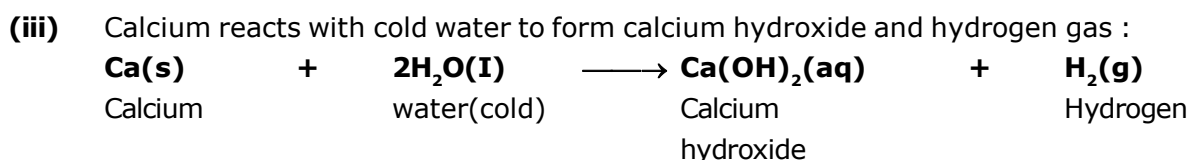
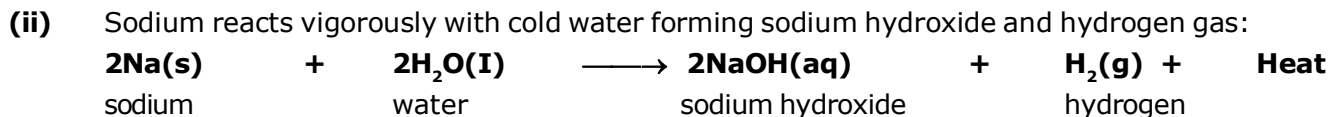
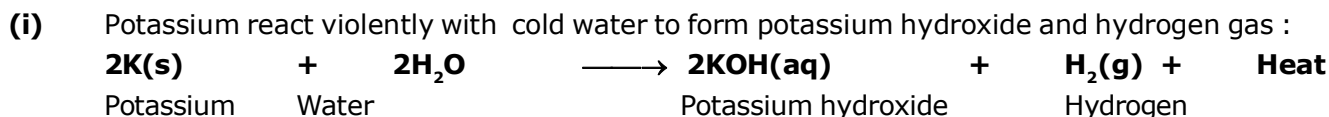


Similarly,

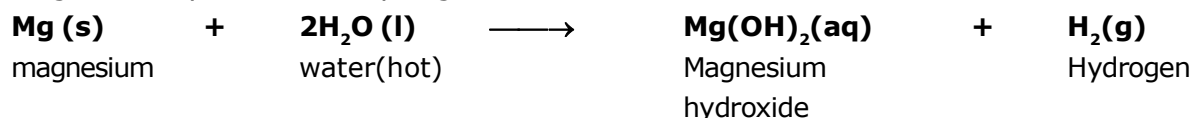
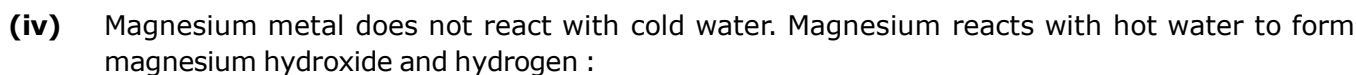


2. Reaction of Metals with water

Metals react with water to form a metal hydroxide (or metal oxide) and hydrogen gas.

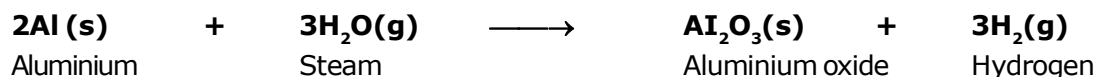
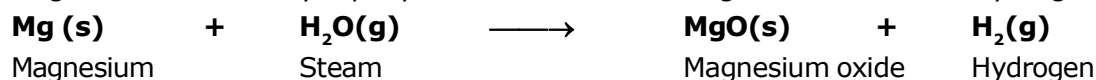


The piece of calcium metal starts floating in water because the bubbles of hydrogen gas formed during the reaction stick to its surface.

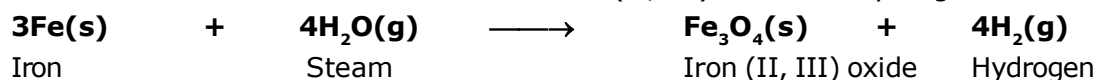
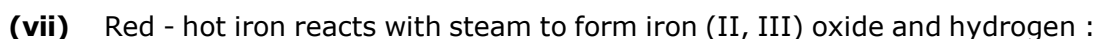
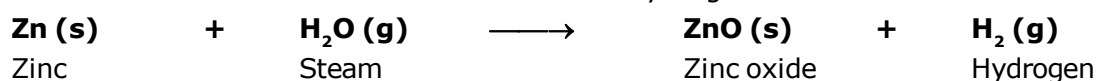
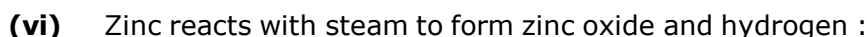


In this reaction the piece of magnesium metal starts floating in water due to the bubbles of hydrogen gas sticking to its surface.

Magnesium reacts very rapidly with steam to form magnesium oxide and hydrogen :



Aluminium metal does not react with water under ordinary conditions because of the presence of a thin (but tough) layer of aluminium oxide on its surface.



Metal like lead, copper, silver and gold does not react with water (or even steam).

ACTIVITY - 7

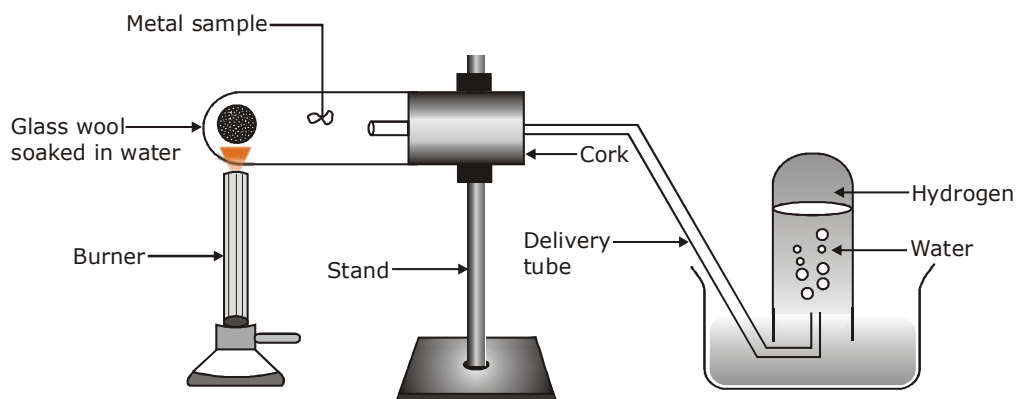
Aim: To study the reactivity of metals with water.

Caution: This activity needs teacher's assistance.

Method:

- Collect the samples of sodium, potassium, calcium, magnesium, zinc and copper.
- Put small piece of the samples separately in beakers half-filled with cold water.
- Put the metals that do not react with cold water in beaker half-filled with hot water.
- For the metals that do not react with hot water, arrange the apparatus (to produce steam) and observe their reaction with steam.





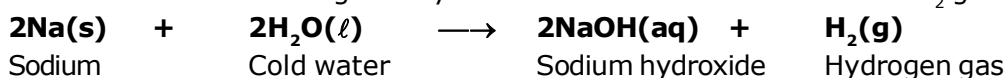
Action of steam on a metal

Now Answer

- Which metals reacted with cold water? Arrange them in increasing order of their reactivity with cold water.
- Does any metal produce fire on water ?
- Does any metal start floating after some time ?
- Which metals did not react even with steam ?

Discussion

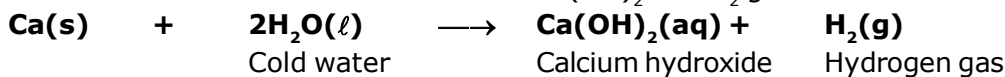
- Na and K metals react vigorously with cold water to form NaOH and H_2 gas is liberated.



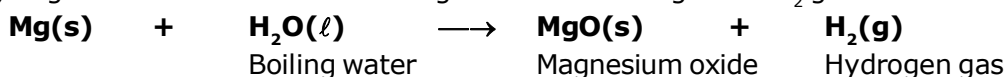
- $2\text{K(s)} + 2\text{H}_2\text{O(l)} \longrightarrow 2\text{KOH(aq)} + \text{H}_2\text{(g)}$
 Potassium Cold water Potassium hydroxide Hydrogen gas

The reactions are so violent and exothermic that the H_2 gas evolved catches fire.

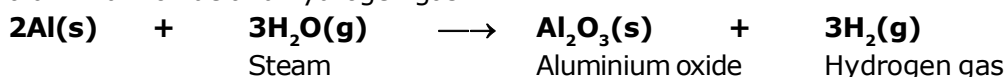
- Calcium reacts with cold water to form Ca(OH)_2 and H_2 gas. It is less violent.



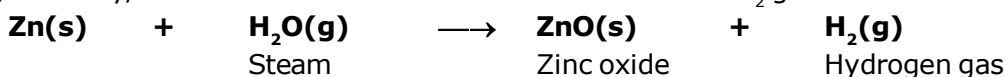
- Magnesium react with hot boiling water to form MgO and H_2 gas.



- Aluminium does not react either with cold or hot water. But it react only with steam to form aluminium oxide and hydrogen gas.



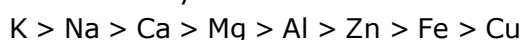
- Similarly, zinc react with steam to form zinc oxide and H_2 gas.



- Copper do not react with water even under strong conditions. The above reactions indicate that sodium and potassium are the most reactive metals while copper is less reactive.

Conclusion

The reactivity order of these metals with water are

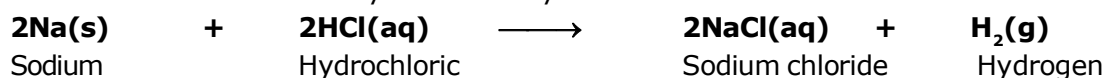


3. Reaction of metals with Dilute Acids :

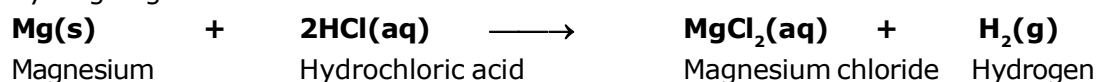
Metals usually displace hydrogen from dilute acids. When a metal reacts with a dilute acid, then a metal salt and hydrogen gas are formed

Metal + Dilute acid \longrightarrow Metal salt + Hydrogen

- Sodium metal reacts violently with dilute hydrochloric acid to form sodium chloride and hydrogen:

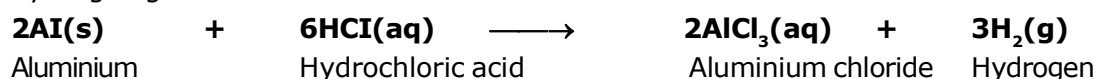


- (ii) Magnesium reacts quite rapidly with dilute hydrochloric acid forming magnesium chloride and hydrogen gas :



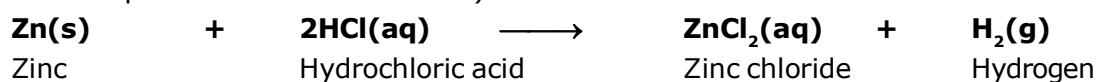
- (iii) Aluminium metal at first reacts slowly with dilute hydrochloric acid due to the presence of a tough protective layer of aluminium oxide on its surface. But when the thin, outer oxide layer gets dissolved in acid.

Aluminium metal reacts rapidly with dilute hydrochloric acid to form aluminium chloride and hydrogen gas :



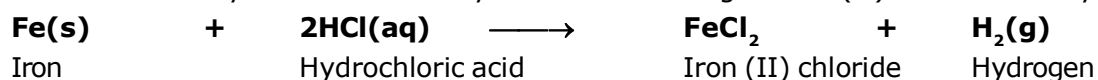
The reaction of aluminium with dilute hydrochloric acid is less rapid than that of magnesium, so aluminium is less reactive than magnesium.

- (iv) Zinc reacts with dilute hydrochloric acid to give zinc chloride and hydrogen gas (but the reaction is less rapid than that of aluminium)

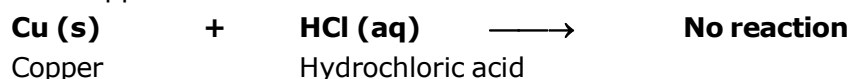


This reaction shows that zinc is less reactive than aluminium.

- (v) Iron reacts slowly with cold dilute hydrochloric acid to give iron (II) chloride and hydrogen gas:



- (vi) Copper does not react with dilute hydrochloric acid (or dilute sulphuric acid) at all. This shows that copper is even less reactive than iron :



Metals like copper and silver which are less reactive than hydrogen, do not displace hydrogen from dilute acids.



REACTION OF METALS WITH SOLUTIONS OF OTHER METAL SALTS

When a more reactive metal is placed in a salt solution of less reactive metal, then the more reactive metal displaces the less reactive metal from its salt solution. This reaction is also known as displacement reaction. Let us learn it with the help of following activity.

ACTIVITY - 8

Aim : To compare the reactivity of the metals.

Procedure : Take a clean wire of copper and an iron nail and two test tubes. Now dissolve copper sulphate in water in one test tube and ferrous sulphate in another test tube. Place iron nail in the blue coloured copper sulphate solution with the help of a thread and copper wire in the greenish colour ferrous sulphate solution as shown in figure as below.

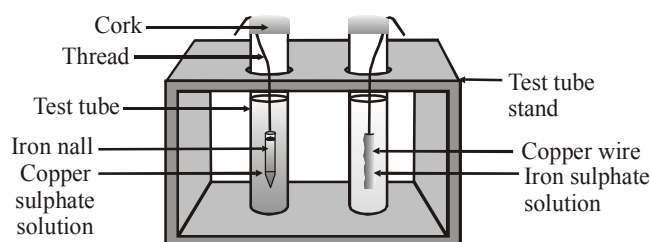
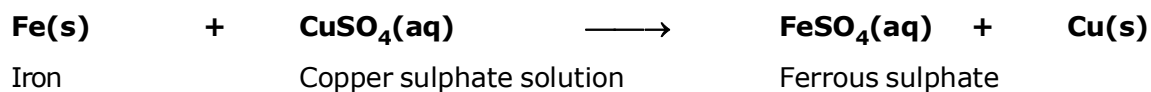


Figure :

Reaction of metals with salt solutions



Observation : The blue colour of copper sulphate has faded and becomes greenish. The green colour of the solution is due to the formation of iron (II) sulphate and copper is displaced. A reddish-brown coating is formed on the surface of iron nail. The reaction is represented by the chemical equation.



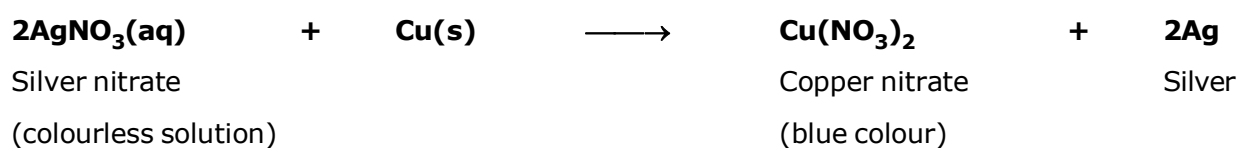
But the greenish colour of FeSO_4 does not change. That means no reaction takes place.

Conclusion : These activities show that iron metal is more reactive than copper.

Similarly,

◆ **REACTION OF COPPER WITH SILVER NITRATE SOLUTION :**

When a strip of copper metal is placed in a solution of AgNO_3 . The solution becomes gradually blue and a shining coating of silver metal gets deposited on the copper strip. The reaction may be written as :



However, if we place silver wire in a copper sulphate solution no reaction occurs. This means copper can displace silver from its salt solution but silver cannot displace copper from its solution. i.e. copper is more reactive metal than silver.

Do You Know?

A piece of Na when thrown in water, catches fire. However it is not the Na, but the hydrogen produced which catches fire.

PROPERTIES OF NON-METALS

◆ **NON-METALS AND THEIR GENERAL PROPERTIES**

Non-metals are present on the right hand side of the periodic table (exception : Hydrogen). Among the total known elements, there are only 22 non-metals, out of which 11 are gases like oxygen, nitrogen, hydrogen one is a liquid (Bromine) and the rest 10 are solids such as sulphur, phosphorus and the allotropes of carbon (Diamond and graphite).

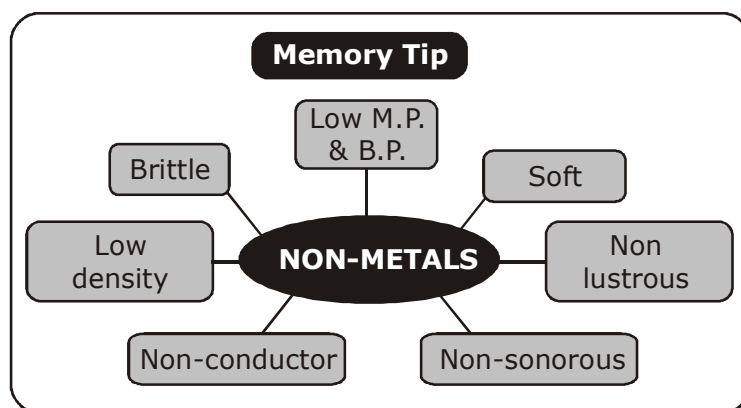
◆ **ELECTRONIC VIEW OF NON-METALS**

An element is called non-metal which forms ions by gaining electrons. For example, oxygen is a non-metal which forms O^{2-} ions by gaining two electrons. Similarly, nitrogen forms N^{3-} ions by gaining three electrons.

Thus, non-metals are also known as electronegative elements.

The atoms of non-metals have usually 4 to 8 electrons in their outer most shell. For example, Carbon (At. No. 6), Nitrogen (At. No. 7), Oxygen (At. No. 8), Fluorine (At. No. 9) and Neon (At. No. 10), have respectively 4, 5, 6, 7 and 8 electrons in their outermost shell. However, there are two exceptions namely hydrogen and helium which have one and two electrons in their valence shell or outer most shell, but they are non-metals.





◆ PHYSICAL PROPERTIES OF NON-METALS

1. **Non-metals are neither malleable nor ductile. Non-metals are brittle (break easily).**

Solid non-metals can neither be hammered into thin sheets nor drawn into thin wires. For example, sulphur and phosphorus are solid non-metals which are non-malleable and non-ductile. The property of being brittle (breaking easily) is called **brittleness**. Brittleness is an important property of non-metals.

2. **Non-metals does not conduct heat and electricity.**

Non-metals does notconduct heat and electricity because unlike metals, they have no free electrons (which are necessary to conduct heat and electricity). For example, sulphur and phosphorus are non-metals which does notconduct heat and electricity. There is, however one exception, carbon (in the form of graphite) is the only non-metal which is a good conductor of electricity because of it's structure.

3. **Non-metals are not lustrous (not shiny). They are dull.**

Non-metals does nothave a shining surface. For example, sulphur and phosphorus are non-metals which have non lustre. Iodine is a non-metal having lustrous appearance.

4. **Non-metals are generally soft (except diamond which is extremely hard non-metal)**

5. **Non-metals are not strong. They are easily broken.**

6. **Non-metals may be solid, liquid or gases at the room temperature.**

7. **Non-metals have comparatively low melting points and boiling points (except diamond which is a non-metal having a high melting point and boiling point).**

The melting point of sulphur is 115°C which is quite low. The melting point of diamond is, however more than 3500°C which is very high.

8. **Non-metals have low densities, that is, non-metals are light substances.**

The density of sulphur of 2g/cm³.

9. **Non-metals are non-sonorous. They does not produce sound when hit with an object.**

10. **Non-metals have many different colours.**

On the basis of the above discussion of the physical properties of metals and non-metals, we have concluded that elements can not be grouped according to the physical properties alone, as there are many exceptions.



For example,

- (i) All metals except mercury are solids at room temperature. We know that metals have very high melting points but gallium (Ga) and caesium (Cs) have very low melting points. These two metals will melt if we keep them at our palm.
- (ii) Iodine is a non-metal but it is lustrous.
- (iii) Alkali metals such as Lithium, Sodium and Potassium are soft and they can be easily cut with a knife. i.e. they have very low densities and low melting points.
- (iv) Carbon is a non-metal that can exist in different forms. Each form is called an allotrope of Diamond, an allotrope of carbon is the hardest natural substance. which has very high melting and boiling point. Graphite is another allotrope of carbon which is good conductor of electricity.

The elements can be more clearly classified as metals and non-metals on the basis of their chemical properties.

Distinction between Metals and Non-metals		
Properties	Metals	Non-metals
Physical properties		
State	Metals are solids at ordinary temperature. Exception. Mercury is a liquid.	Non-metals exist in all the three states, that is, solid, liquid and gas.
Lustre	They possess lustre or shine.	They possess no lustre. Exceptions: Iodine and graphite.
Malleability and Ductility	Metals are generally malleable and ductile.	Non-metal are neither malleable nor ductile.
Hardness	Metals are generally hard. Alkali metals are exceptions.	Non-metal possess varying hardness. Diamond is an exception. It is the hardest substance known to occur in nature.
Density	They have high densities.	They generally possess low densities.
Conductivity	Metals are good conductors of heat and electricity.	Non-metals are poor conductors of heat and electricity. The only exception is graphite which is a good conductor of electricity.
Melting and boiling points	They usually have high melting and boiling points.	Their melting and boiling points are usually low. The only exceptions are boron, carbon and silicon.

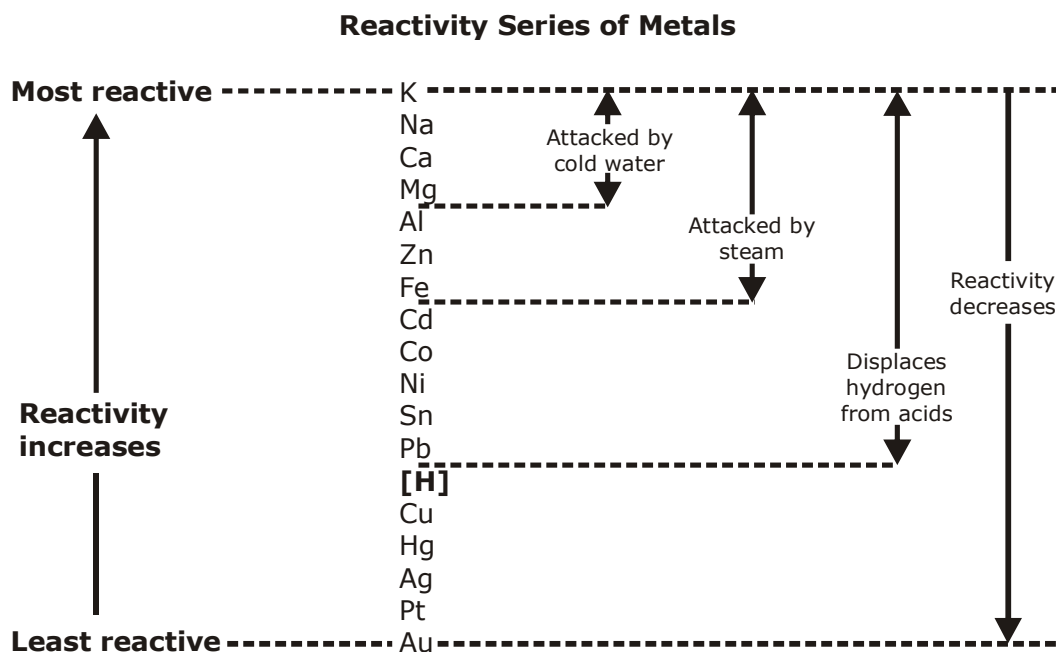


Distinction between Metals and Non-metals		
Properties	Metals	Non-metals
Chemical properties		
Action with mineral acids	Metals generally react with dilute mineral acids to liberate H ₂ gas.	Non-metals do not displace hydrogen on reaction with dilute minerals acids.
Nature of oxides	They form basic oxides. For example, Na ₂ O, MgO, etc. These oxides are ionic in nature.	Non-metals form acidic or neutral oxides. For example, SO ₂ , CO ₂ , P ₂ O ₅ , etc. are acidic whereas CO, N ₂ O, etc. are neutral. These oxides are covalent in nature.
Combination with hydrogen	Metals generally do not combine with hydrogen. However, Li, Na, Ca, etc. form unstable hydrides. For example, LiH, NaH, CaH ₂ etc. These hydrides are ionic in character.	Non-metals combine with hydrogen to form stable hydrides. For example, KCl, H ₂ S, CH ₄ , NH ₃ , PH ₃ , etc. These hydrides are covalent.
Combination with halogens	They combine with halogens to form well defined and stable crystalline solids. For example, NaCl, KBr, etc.	Non-metals form halides which are unstable and undergo hydrolysis readily. For example PCl ₅ , PCl ₃ , etc.
Electrochemical behaviour	Metals are electropositive in character. They form cations in solution and are deposited on the cathode when electricity is passed through their solution.	Non-metals are electronegative in character. They form anions in solution and are liberated at the anode when their salt solutions are subjected to electrolysis. Hydrogen is an exception. It usually forms positive ions and is liberated at cathode.
Oxidising or reducing behaviour	Metals behave as reducing agents. This is because of their tendency to lose electrons. $\text{Na} \longrightarrow \text{Na}^+ + \text{e}^-$	Non-metals generally behave as oxidising agents since they have the tendency to gain electrons. $\frac{1}{2} \text{Cl}_2 + \text{e}^- \longrightarrow \text{Cl}^-$



THE REACTIVITY SERIES

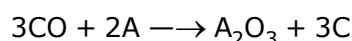
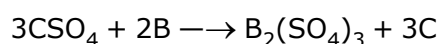
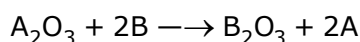
The arrangement of metals in order of decreasing reactivities is called reactivity series or activity series of metals. After performing displacement experiments the following series has been developed.



◆ CHARACTERISTICS OF REACTIVITY SERIES:

- (i) The most reactive metal is placed at the top and the least reactive metal is placed at the bottom of the table.
- (ii) Metals present above the hydrogen in reactivity series can displace hydrogen from dilute acids.
- (iii) A metal can displace the metals placed below it in the reactivity series.
- (iv) Metals present at the top are more electro-positive, so they will occur in combined or compound form only in nature.
- (v) Metals at the bottom are less reactive and do not react easily so they may be present in free state in nature.

Ex.1 A, B and C are three elements which undergo chemical change according to the following equations :



Write the name of the most reactive and the least reactive elements.

- Sol.**
- (i) In the first reaction, B displaces A, so B is more reactive than A.
 - (ii) In second reaction, B displaces C, so B is more reactive than C.
 - (iii) In third reaction, A displaces C, so A is more reactive than C.

So, B is more reactive than A and C and A is more reactive than C, So the order of their reactivities is as follows:

$$B > A > C$$



METALS AND NON-METALS

Ex.2 Explain why zinc metal can displace copper from copper sulphate solution but copper cannot displace zinc from zinc sulphate solution.

Or

When a piece of copper metal is added to a solution of zinc sulphate, no change takes place, but the blue colour of copper sulphate fades away when a piece of zinc is placed in its solution.

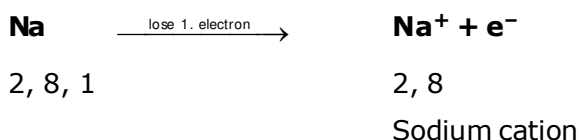
Sol. When a piece of zinc is placed in a solution of copper sulphate, zinc being more reactive than copper, can displace copper from its salt solution and forms zinc sulphate and blue colour of copper sulphate fades away slowly, but when a piece of copper sulphate fades away slowly, but when a piece of copper metal is added to a solution of zinc sulphate, no change takes place as copper being less reactive than zinc, cannot displace zinc from zinc sulphate.

ELECTRONIC CONFIGURATION OF SOME ELEMENTS :

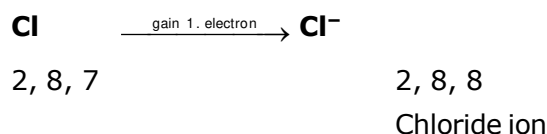
Types of element	Element	Atomic number	Number of electrons in shells			
			K	L	M	N
Noble gases	Helium (He)	2	2			
	Neon (Ne)	10	2	8		
	Argon (Ar)	18	2	8	8	
Metals	Sodium (Na)	11	2	8	1	
	Magnesium (Mg)	12	2	8	3	
	Aluminium (Al)	13		2	8	3
	Potassium (K)	19	2	8	8	1
	Calcium (Ca)	20	2	8	8	2
Non-Metals	Nitrogen (N)	7	2	5		
	Oxygen (O)	8	2	6		
	Fluorine (F)	9	2	7		
	Phosphorus (P)	15	2	8	5	
	Sulphur (S)	16	2	8	6	
	Chlorine (Cl)	17	2	8	7	

HOW ARE METAL AND NON METAL REACT?

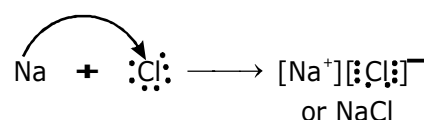
It is clear from the above table that except helium, all other noble gases have 8 electrons (octet) in their outermost shell. Which represent a highly stable electronic configuration. Due to this stable configuration, the noble gases have no any tendency to lose or gain electrons. So they exist monoatomic, sodium atom has one electron in its outermost shell. If it loses the electron from its M shell the its L shell becomes the outermost shell. which has stable octet like noble gases. The nucleus of this atom still has 11 protons but the number of electrons has 10. Therefore, it becomes positively charged sodium ion or cation (Na^+).



On the other hand chlorine has seven electrons in its outer most shell and it require one more electron to complete its octet. The nucleus of chlorine atom has 17 protons and the number of electrons become 18. This makes chloride ion, Cl^- as negatively charged

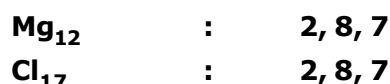


So, Na^+ and Cl^- ions being oppositely charged atoms which attract each other and are held by strong electrostatic forces of attraction to exist as NaCl. In other words, Na^+ and Cl^- ions are held together by electrovalent or ionic bond.



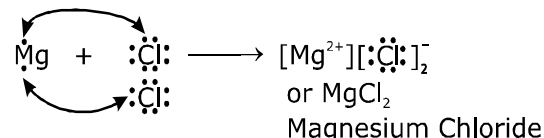
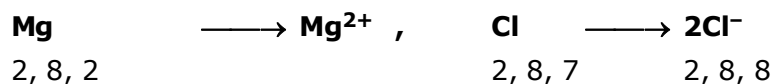
The formation of one more ionic compound magnesium chloride :

The electronic configuration of magnesium (Mg) and chlorine atoms are :



Magnesium atom has two electrons in its valence shell. It has a tendency to lose both of its electrons to attain the nearest noble gas configuration (i.e. Ne). $\text{Mg} \longrightarrow \text{Mg}^{2+}$.

On the other hand, chlorine has only one electron less than the nearest noble gas (i.e. Ar) configuration. The magnesium loses its both the valence electrons to two chlorine atoms, each of which is need of one electron to form Cl^- ion.



The compounds formed by the transfer of electrons from a metal to a non-metal are known as ionic compound or electrovalent compounds. The structure of some common ionic compounds are given below :

Structure of some common ionic compounds :

1.	Magnesium oxide	Mg	+	O	$\longrightarrow \text{Mg}^{2+}[\text{O}]^{2-}$	or	MgO
		2, 8, 2		2, 6			
2.	Magnesium fluoride	Mg	+	2F	$\longrightarrow \text{Mg}^{2+}2[\text{F}]^-$	or	MgF_2
		2, 8, 2		2, 7			
3.	Calcium oxide	Ca	+	O	$\longrightarrow \text{Ca}^{2+}[\text{O}]^{2-}$	or	CaO
		2, 8, 8, 2		2, 6			
4.	Aluminium oxide	Al	+	O	$\longrightarrow 2\text{Al}^{3+}3[\text{O}]^{2-}$	or	Al_2O_3
		2, 8, 3		2, 6			
5.	Magnesium Chloride	Mg	+	2Cl	$\longrightarrow \text{Mg}^{2+}2[\text{Cl}]^-$	or	MgCl_2
		2, 8, 2		2, 8, 7			
6.	Aluminium nitride	Al	+	N	$\longrightarrow \text{Al}^{3+}\text{N}^{3-}$	or	AlN
		2, 8, 3		2, 5			



ACTIVITY - 9

Aim: To study the properties of ionic compounds.

Method:

- (i) Take samples of sodium chloride, potassium iodide, barium chloride or any other salt from the science laboratory.
- (ii) Take a small amount of sample on a metal spatula and heat directly on the flame. Repeat with other samples.
- (iii) Try to dissolve the compound in water and kerosene.
- (iv) Make a circuit as shown in figure and insert the electrodes into a solution of one salt. Test the other salt samples too in this manner.

Now Answer

- (i) What is the physical state of the salt taken ?
- (ii) Did the samples impart any colour to the flame on heating ?
- (iii) Did the compounds melt on heating?
- (iv) Are the compounds soluble in water or kerosene ?
- (v) Did the electric bulb glow on passing electric current ?
- (vi) What is your inference about the nature of these compounds?

Discussion

- (i) All the salts taken are solids. Each salt imparted a particular colour to the flame.
- (ii) The compounds did not melt on heating.
- (iii) The compounds were soluble in water but not in kerosene.
- (iv) The electric bulb glows on passing electric current. All these properties show that the compounds are ionic in nature.

Conclusion

- (i) Ionic compounds are generally solids.
- (ii) They impart a characteristic colour to the flame.
- (iii) They are soluble in a polar solvent like water and insoluble in non-polar solvent like kerosene, petrol, etc.
- (iv) Their molten or aqueous solution conduct electricity.

• **Following are the general properties of ionic compounds.**

(a) Physical state

Ionic compounds are solids and relatively hard because of the strong force of attraction between the positive and negative ions. This force of attraction is also known as strong electrostatic force of attraction. These compounds are generally brittle and break into pieces when pressure is applied.

(b) Solubility

Electrovalent compounds are generally soluble in water (because of their polar nature) and insoluble in solvents such as kerosene, petrol, etc.

(c) Melting and boiling points

Ionic compounds have high melting and boiling points, due to the strong electrostatic force of attraction between the oppositely charged ions. Therefore, large amount of energy is needed to break these bonds.

(d) Conduction of electricity

Ionic compounds in the solid state do not conduct electricity because movement of ions in the solid state is not possible due to their rigid structure. But they can conduct electricity in molten or aqueous state.



(e) Colour to the flame

Most of the salts when brought into the flame, impart characteristic colour to the flame.

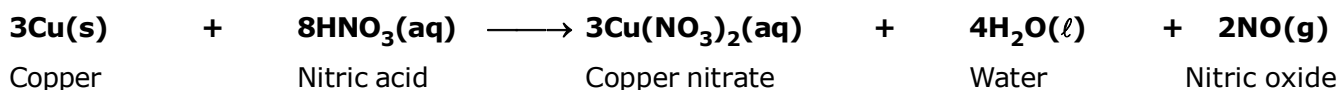
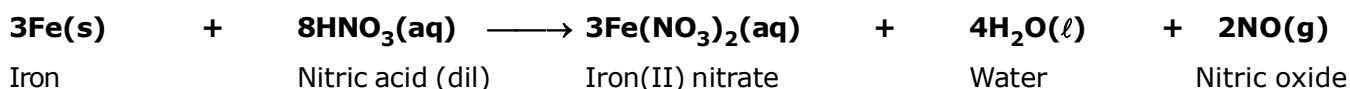
Ionic Compound	Melting Point (K)	Boiling Point (K)
NaCl	1074	1738
LiCl	878	> 1570
KBr	1007	1708
KI	953	1600
CaCl ₂	1055	1870
CaO	2845	3123
MgCl ₂	987	1685

Do You Know?

Gallium metal has such a low melting point (30°C) that it melts from the heat of a hand.

IMPORTANT INFORMATION

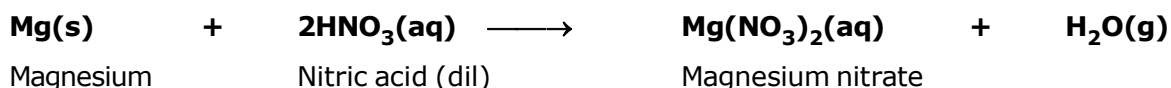
Hydrogen gas is not evolved when metals such as Zn, Fe, Cu and Al reacts with nitric acid. Because HNO₃ is strong oxidising agent. It oxidises H₂ gas to water and itself gets reduced to form oxides of (NO, N₂O and NO₂) nitrogen.



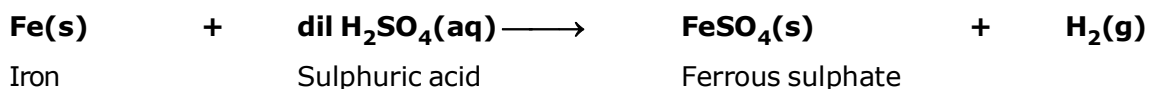
But copper reacts with hot concentrated sulphuric acid (H₂SO₄) to produce copper sulphate, sulphur dioxide and water.



Mg reacts with very dilute HNO₃ to evolve H₂ gas.



Fe react with dil H₂SO₄ to evolve H₂


AQUA REGIA (ROYAL WATER)

Aqua regia is a Latin word it means "royal water". It is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3 : 1. It is a highly corrosive, fuming liquid and it is used to dissolve gold and platinum.



OCCURENCE OF METALS

The main source of metal is earth's crust. Some metals also occur in sea water. The metals are found in nature in :

- (1) **Native state (or free state)** : Only a few less reactive metals like silver, gold platinum etc., are found in the free state in which they are called "native metals".
- (2) **Combine state** : i.e., in the form of their compounds admixed invariably with various useless impurities such as clay, sand, rocky material, etc. Usually, metals are found in the form of oxides, sulphides, carbonates, phosphates, halides silicates, etc.
 - (i) The naturally occurring form of metal in combined state, is known as "mineral".
 - (ii) Those naturally occurring minerals, which are economically suitable for commercial extraction of metals, are known as 'ores'. Thus, every ore is a mineral, but every mineral is not an ore.
 - (iii) The rocky and earthy impurities (like clay, sand) generally associated with ore, are called gangue (or matrix).

TYPES OF ORES

Nature of ore	Metal		Composition
Oxide Ores	Aluminium	Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
	Copper	Cuprite	Cu_2O
	Iron	Magnetite	Fe_3O_4
Sulphide Ores	Copper	Copper pyrites	CuFeS_2
		Copper glance	Cu_2S
	Zinc	Zinc blende	ZnS
	Lead	Galena	PbS
	Mercury	Cinnabar	HgS
Carbonate Ores	Calcium	Limestone	CaCO_3
	Zinc	Calamine	ZnCO_3
Halide Ores	Sodium	Rock salt	NaCl
	Magnesium	Camallite	$\text{KCl MgCl}_2 \cdot 6\text{H}_2\text{O}$
	Calcium	Fluorspar	CaF_2
	Silver	Horn silver	AgCl
Sulphate Ores	Calcium	Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
	Magnesium	Epsom Salt	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
	Barium	Barytes	BaSO_4
	Lead	Anglesite	PbSO_4

Note :

- (1) Sodium a very reactive metal, and reacts readily with moisture, oxygen and carbon dioxide of air. So sodium cannot exist 'free' in nature. Hence, it is not found 'native' in nature.
- (2) Sodium is highly reactive metal, and has affinity for oxygen. If it is exposed to air, a coating of the oxide is formed and sometimes, it may even catch fire. Consequently, sodium metal should not be exposed to air. Hence, sodium is stored under kerosene.
- (3) Aluminium is a reactive metal, so it is not found in free state in nature. It occurs in the form of its compounds, chief of which is bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$).
- (4) Gold and silver occupy low position in the activity series. Consequently, they are least reactive elements and are not effected by most chemicals, atmospheric oxygen, moisture, carbon dioxide etc. Hence, they often occur in free or native state in nature.



Extraction of metals : We have learnt about the reactivity series of metals, according to which, the metals at the “bottom” of the reactivity series are the “least reactive” and these are often found in a free-state, e.g., Au, Ag, Pb and Cu. However Cu and Ag are also found in combined state as their oxides and sulphides. On the other hand, metals at the “top” of the reactivity series are so reactive, they are never found in nature as free elements, e.g., Li, K, Na, Ca, Mg etc. The metals in the “middle” of the reactivity series (e.g., Al, Zn, Fe, Pb etc.) are moderately reactive and they are found in the earth’s crust mainly as oxides, sulphides or carbonates [e.g., $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ (bauxite), HgS (cinnabar), ZnCO_3 (calamine)].

On the basis of reactivity series, we can have following three groups of elements :

(i) Metals of low reactivity.

(ii) Metals of medium reactivity.

(iii) Metals of high reactivity.

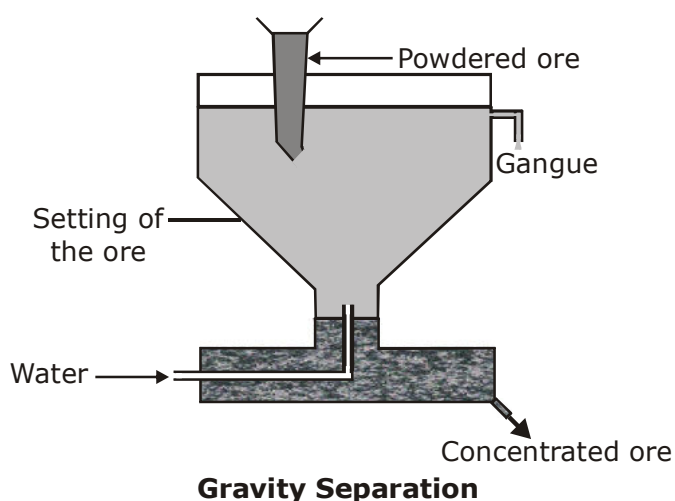
Metallurgy : is the process of extracting a metal in the free form from its ore and then refining it for use. Various steps involved in the extraction of metals from their ores are generally as follows:

- (a) Concentration (or enrichment) of ore
- (b) Conversion of concentrated ore into oxide
- (c) Reduction of oxide ore into impure metal
- (d) Refining of impure metal.

(a) Concentration (or enrichment) of ore : The ore is, generally, associated with useless rocky and earthy impurities (like clay, sand etc.), called ‘gangue’ or matrix. The ‘concentration’ (or enrichment) of ore means removal of gangue from the powdered ore. Thus, the percentage of the metal in the concentrated ore is higher than that in the original ore. The concentration of ore can be brought about in the following ways. depending upon the type of ore such as hydraulic washing, froth floatation method, magnetic separation etc.

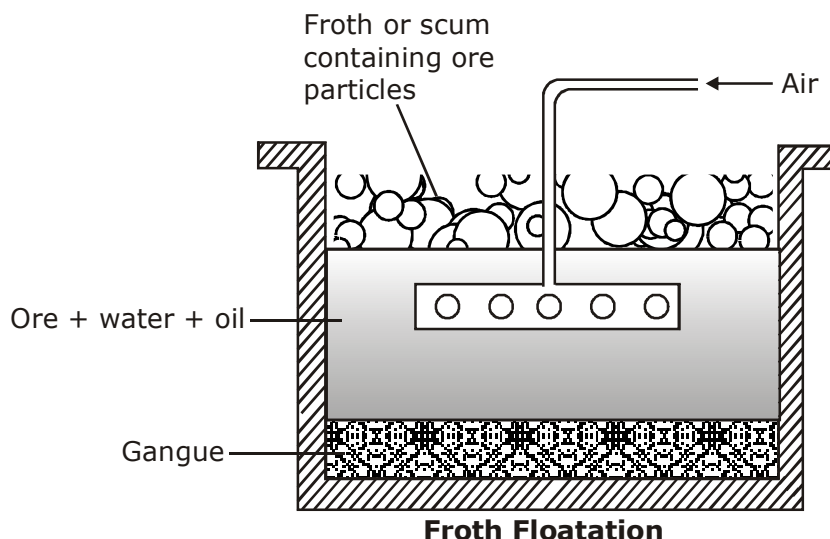
(i) Levigation or gravity separation or hydraulic washing

This method is based upon the difference in the densities of the ore particles and impurities (gangue). Example: Haemetite ore of iron.



(ii) Froth floatation

This method is based on the difference in the wetting properties of the ore and gangue particles with water and oil. It is used for enrichment of sulphide ores. Example: ZnS , HgS .

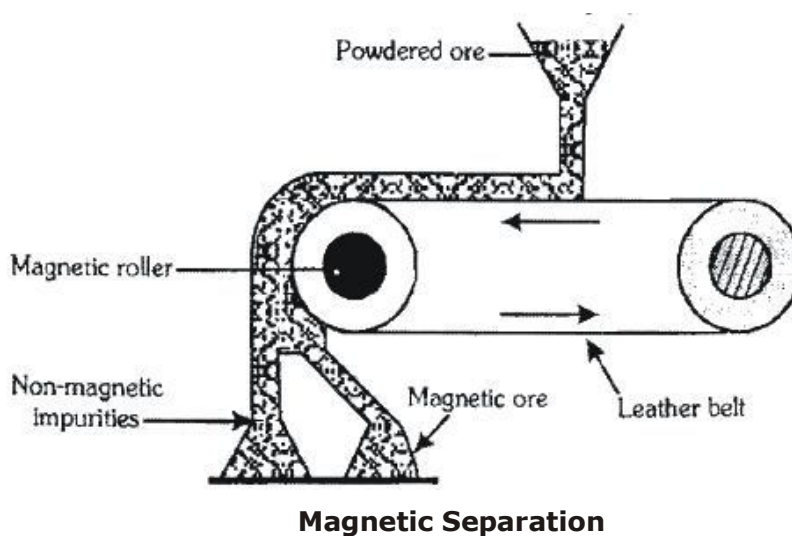


(iii) Liquation

This method is based on difference in melting point of ore and gangue particles. Example: ore of tin and zinc.

(iv) Magnetic separation

This method is based on difference in the magnetic properties of the ore and gangue. Example: magnetite (Fe_3O_4) ore of iron.



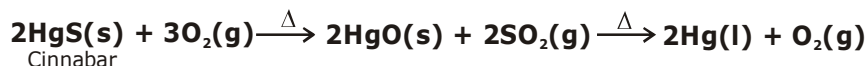
(v) Chemical separation

When none of the physical property makes the difference, then we use chemical properties as the basis for enrichment. e.g. Bayer's process for alumina enrichment.



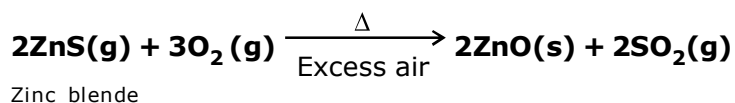
Next steps of metallurgy depend on the type of metal to be extracted :

(a) Extracting metals low in reactivity series : Since these metals are unreactive, so the oxides of these metals can be "reduced" by heating alone. For example, cinnabar (HgS) an ore of mercury changes to mercury on heating

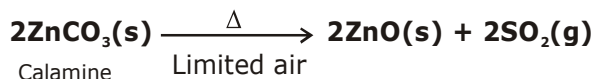


(b) Extracting metals in the middle of the reactivity series : Since these metals (e.g. Fe, Zn, Pb, Cu, etc.) are moderately reactive, so they are usually found in earth's crust as sulphides or carbonates. Consequently are converted into metal oxides.

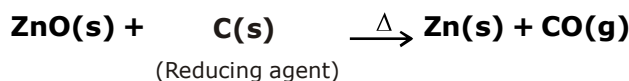
(i) The process of conversion of metal sulphide to oxide by strongly heating in the presence of excess air, is called roasting. For example :



(ii) The process of conversion of metal carbonate to oxide by heating strongly in limited air, is called calcination. For example :



Reduction of oxide to metal : The metal oxides obtained above are reduced by heating with suitable reducing agents like carbon. For example :



It may be pointed out here that besides using carbon (coke), to reduce metal oxides to metals, sometimes, displacement reactions are also employed. The highly reactive metals (e.g., Na, Ca, Al, etc.) are employed as reducing agents, since they displace metals of lower reactivity from their compounds, For example :



Such a displacement reaction is highly exothermic (i.e., lot of heat is evolved), so the metal produced is in molten state [e.g., Mn(l)] Al is also used to reduce iron (III) oxide (Fe_2O_3) and this reaction is called thermite reaction and used to join railway tracks or machine parts.



Do You Know?

The reaction in which one of the reactant (Cu_2S) carries the reduction of the product (Cu_2O) is known as auto reduction.

Difference between Roasting and Calcination

Roasting	Calcination
1. The ore is heated in the presence of air (oxygen).	1. The ore is heated in the absence of air (oxygen).
2. It is used to convert sulphide ores into oxides ores.	2. It is used to convert carbonate ores into oxides ores.
Sulphide ore $\xrightarrow{\text{Roasting}}$ Oxide ore	Carbonate ore $\xrightarrow{\text{Calcination}}$ Oxide ore



Do You Know?

It is easy to extract a metal from its oxide, as compared to its sulphide or carbonate.

(c) Extracting metals near the top of the reactivity series : Since these metals are highly reactive, so their oxides cannot be reduced by heating with carbon. For example, $\text{Na}_2\text{O(s)}$, MgO(s) , CaO(s) , $\text{Al}_2\text{O}_3\text{(s)}$, etc. cannot be reduced by heating with carbon. This is because these metals possess more affinity for oxygen than carbon. Consequently, these metals are extracted by electrolytic reduction process. For example, when molten sodium chloride is electrolysed sodium is obtained at the cathode (the negatively charged electrode) : while chlorine is liberated at the anode (the positively charged electrode).

Thus : At cathode : $\text{Na}^+ + \text{e}^- \longrightarrow \text{Na(s)}$

At anode : $2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$

Likewise, Al is obtained by the electrolytic reduction of Al_2O_3 .

(d) Refining of metals : the process of purifying the crude metal to get pure metal, is called refining. The method of metal refining depends on :

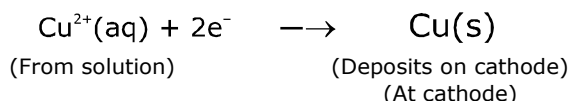
(i) the nature of the metal to be purified and (ii) the type of impurities present.

Electrolytic refining : Most of the metals are refined by this method. In this process, a large block of impure metal is made the anode in an electrolytic cell, and a thin sheet of pure metal is made the cathode. Suitable metal salt solution is made as an electrolyte. On passing electric current, pure metal deposits on the cathode sheet; while some of impurities are left in solution, and other noble metal impurities settle below the anode as 'anode mud'.

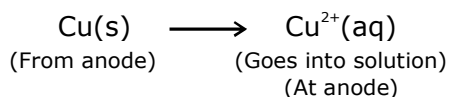
For example, during the electrolytic refining of a copper, a thick block of impure copper is made anode, and thin plate of pure copper is made cathode. Copper sulphate solution. is used as an electrolyte.

On passing electric current, following reactions take place :

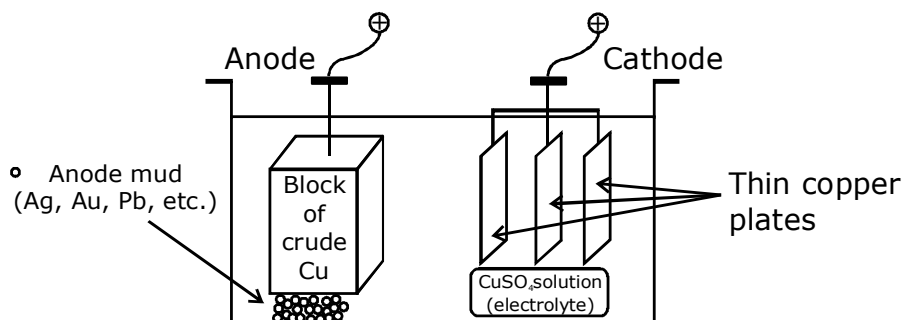
(1) Cu^{2+} ions (from copper sulphate solution) go to the cathode (negative electrode), where they are reduced to copper, which gets deposited on the cathode.



(2) Copper (of impure anode) forms copper ions and these go into solution of electrolyte.



Thus, the net result is transfer of pure copper from anode to the cathode. Impurities like zinc, iron etc., go into solution; while noble impurities like silver, gold etc., are left behind as anode mud.



CORROSION

Any process of deterioration (or destruction) and consequent loss of a solid metallic material, through an unwanted (or unintentional) attack by its environment, starting at its surface, is called corrosion. Thus, corrosion is a process "reverse of extraction of metals".

The most familiar example of corrosion is rusting of iron, when exposed to the atmospheric conditions. During this, a layer of reddish scale and powder of oxide ($\text{Fe}_2\text{O}_3 \cdot x \text{H}_2\text{O}$) is formed and the iron becomes weak. Another common example is formation of green films of basic copper, when exposed to moist-air containing carbon dioxide. Similarly, silver article turns black after some time, when exposed to air. This is due to the reaction of Ag with H_2S present in air to form black coloured Ag_2S .

Note :

- (i) It may be pointed out that noble metals such as gold and platinum do not corrode easily.
- (ii) The process of corrosion is continuous and causes decrease in strength of the metal.

Prevention of rusting :

(i) By painting: The corrosion of a metal can be prevented simply by painting the metal surface by grease or varnish which forms a protective layer on the surface of the metal which protects the metal from moisture and air.

(ii) Self prevention: Some metals form protective layers.

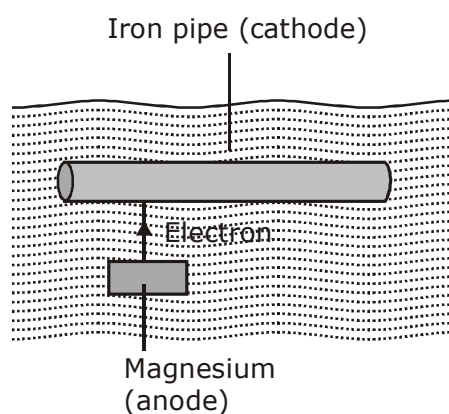
For example: When zinc is left exposed to the atmosphere, it combines with the oxygen of air to form a layer of zinc oxide over its surface. The oxide layer does not allow air to go inside the metal. Thus, zinc is protected from corrosion by its own protective layer.

Similarly, aluminium combines with oxygen to form a dull layer of aluminium oxide on its surface which protects the aluminium from further corrosion.

(iii) Cathodic protection: In this method the more reactive metal which is more corrosion-prone is connected to a bar of another metal which is less reactive and to be protected. In this process electron flow from the more reactive metal to the less reactive metal. The metal to be protected becomes the cathode and the more reactive metal becomes the anode.

In this way, the two metals form an electrochemical cell and oxidation of the metal is prevented.

Example: The pipelines (iron) under the surface of the earth are protected from corrosion by connecting them to a more reactive metal (magnesium or Zn) which is buried in the earth and connected to the pipelines by a wire.



Cathodic Protection

(vi) Oiling and greasing: Both protect the surface of metal against moisture and chemicals etc. In addition the oil and grease prevent the surface from getting scratched.



(v) Electroplating: It is a very common and effective method to check corrosion. The surface of metal is coated with chromium, nickel or aluminium etc. by electrolysis also called **electroplating**. They are quite resistant to the attack by both air and water and check corrosion. If the surface of metal is electroplated by zinc, it is known as **galvanisation** and in case tin metal is used, then the process is called **tinning**.

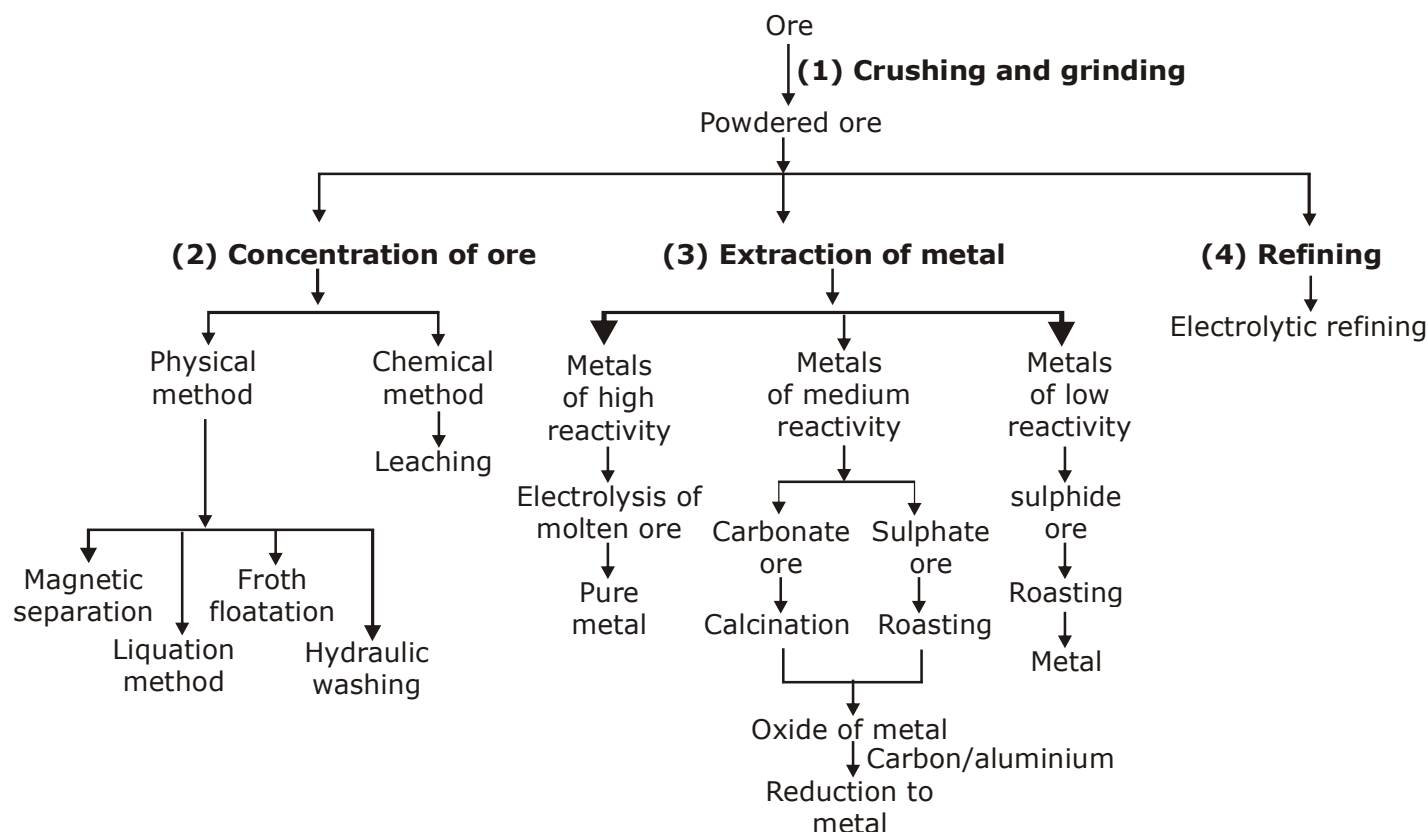
(vi) By alloying: It is a very good method of improving the properties of a metal.

For example: Iron is the most widely used metal. But it is never used in its pure state. This is because pure iron is very soft and stretched easily when hot. But, if it is mixed with a small amount of carbon (about 0.05%) it becomes hard and strong.

When iron is mixed with nickel and chromium to form stainless steel which is hard and does not rust, i.e. its properties change. In fact, the properties of any metal can be changed, if it is mixed with some other substances.

Importance of corrosion : Sometimes corrosion of a metal prevents further corrosion of the underlying metal : For example, when Al is exposed to air a thin coating of Al_2O_3 on the metal article is formed. This film, quite adhering and non-porous, thereby it protect the Al metal underneath from further corrosion and damage. This is the reason why Al, being a very reactive metal, is used for making utensils.

PROCESS OF METALLURGY



ALLOYING

"An alloy is a homogeneous solid solution of one metal with one or more metals or non-metals." such as brass, bronze, steel etc.

Purposes of alloy making : Alloys are generally, made to serve one or more of the following purposes:

- (i) To modify chemical activity such as increased resistance to corrosion.
- (ii) To harden a metal e.g., copper in gold ornaments.
- (iii) To increase the strength and toughness.
- (iv) To lower the melting point.
- (v) To produce good castings.

For instance, pure iron is very soft and stretches easily, but it is mixed with some metals and non-metals, the alloys formed show considerable improvement in the qualities.

- (i) **Steel :** When iron has carbon (0.05 to 0.5%) it is called steel. It is hard and strong. It is used for making ships, vehicles and building.
- (ii) **Stainless Steel :** When steel is mixed with nickel and chromium, it is called stainless steel. It is hard and rust-proof. It is used for making utensils, equipments for feed and dairy industry.

Some common Alloys

- (i) **Brass :** It is an alloy of copper and zinc (Cu-60 to 90%; Zn-10 to 40%). It is a yellow coloured alloy and used for making utensils, coins and decorative pieces.
- (ii) **Bronze :** It is an alloy of copper and tin (Cu-88 to 96%; tin-4 to 12%). It is shining light, yellowish coloured alloy. It is used for making statues, ships and medals.
- (iii) **Solder :** It is an alloy of lead and tin (lead 33%; tin 67%). Its melting point is low. It is used for soldering electrical wires.
- (iv) **Alloying of gold :** The purity of gold is expressed in 'carat' and 24 carat gold is supposed to be 100% pure. Pure gold or 24 carat gold is very soft and cannot be used for making ornaments. To make it hard, it is alloyed with silver, copper or both. Mostly 22 carat or 20 carat gold is used for making ornaments. 22 carat gold means 22 parts of pure gold mixed with 2 parts of silver or copper or both.
- (v) **Duralumin:** It is an alloy of aluminium. It contains 95% of aluminium, 4% of copper, magnesium is 0.5% and 0.5% of manganese. It is stronger and lighter than aluminium. Duralumin is used for making bodies of air crafts, helicopters, jets, kitchen ware like pressure cooker. It is also used for making bodies of ships (due to its resistance to sea water corrosion). It is also known as duralium.
- (vi) **Amalgam:** It is an alloy of mercury and one or more other metals is known as an amalgam. It may be solid or liquid. A solution of sodium metal in liquid mercury metal is called sodium amalgam, which is used as a reducing agent. Amalgam of silver, tin and zinc is used by dentists for filling in teeth.



SOLVED PROBLEMS

Ex.1 What determines the reactivity of metals ?

Sol. If a metal atom lose one or more electrons easily to form positive ions, it will react readily with other substance. Thus, a more electropositive element is more reactive and a less electropositive element is less reactive. Electropositive character of a metal determines its reactivity.

Ex.2 Write a short note on a reactivity series of metals ?

Sol. Some metals are very reactive while others are less reactive or does not react at all. For example, sodium and potassium reacts very vigorously even with cold water, so they can be said to be very reactive metals. Zinc and iron does not reacts with hot water, but reacts with steam, so they are less reactive metals. On the other hand, copper and silver does not reacts even with steam, so they are quite unreactive metals. Thus, on the basis of vigourousity with which various metals react with oxygen, water and acids the metals have been arranged in a series. The below arrangement of metals in a vertical column in decreasing order of reactivity is called the activity series of metals.

REACTIVITY OR ACTIVITY SERIES OF METALS :

Property	Elements	Symbol
These metals are more reactive than hydrogen and displace H_2 gas from dilute acids.	Potassium	K \longrightarrow Most reactive
	Sodium	Na
	Barium	Ba
	Calcium	Ca
	Magnesium	Mg
	Aluminium	Al
	Zinc	Zn
	Iron	Fe
	Nickel	Ni
	Tin	Sn
	Lead	Pb
	Hydrogen	H
These metals are less reactive than hydrogen	Copper	Cu
	Mercury	Hg
	Silver	Ag
	Gold	Au
	Platinum	Pt \longrightarrow Least reactive

Ex.3 Explain, why some metals are more reactive and others less reactive ?

Sol. When metals react, they lose electrons to form positive ions. Such metals which can lose electrons easily to form positive ions when reacted with other substance, are reactive metals. On the other hand, if a metals loses electrons less rapidly as compare to more reactive metal to form positive ions, it will react slowly with other substances. Such a metal will be less reactive.

Example : Sodium atom is a very reactive metal because it readily loses one electrons, forms a positive ion which then combines with other substances. On the other hand, lead atom loses electrons with difficulties to form positive ions, so lead metal is less reactive.



Ex.7 List six differences in the physical properties of metals and non-metals ?

Sol.	Property	Metal	Non - metal
	1. Physical state	All metals are solids except mercury which is liquid.	Non - metals exist in all three states. H_2 , O_2 and N_2 are gases. bromine is a liquid ; carbon,sulphur and phosphorus are solids.
	2. M.pt. and B. pts.	Most of the metals have high melting and boiling points.	The melting and boiling points of non-metals are comparatively low.
	3. Lustre	Metals show bright metallic lustre.	These are generally dull except iodine.
	4. Malleability	Malleable, i.e., can be beaten to thin sheets or foils.	Not malleable
	5. Ductility	They are ductile i.e., can be drawn into wires.	Not ductile
	6. Conductivity	They are good conductors of heat and electricity	They are bad conductors of heat and electricity (except graphite)

Ex.8 Give a comparison of chemical properties of metals with those of non - metals.

Sol. Chemical Properties :

Metals	Non - metals
1. Metals form basic oxides, some of them form alkalies.	1. Non - metals form acidic or neutral oxides.
2. Metals replace hydrogen from acids and form salts.	2. Non - metals does not replace hydrogen from acids.
3. With chlorine, metals form chlorides which are electrovalent.	3. With chlorine non - metals form chlorides which are covalent.
4. With hydrogen few metals form hydrides which are electrovalent.	4. With hydrogen non-metals form many stable hydrides which are covalent.

Ex.9 Write a note on the "solubility" of ionic compounds ?

Sol. Ionic compounds are generally soluble in polar solvents like water because molecules of the polar solvents strongly interact with the ions of the crystal and the solvation energy so released is sufficient to overcome the attraction between the ions in the crystal lattice.

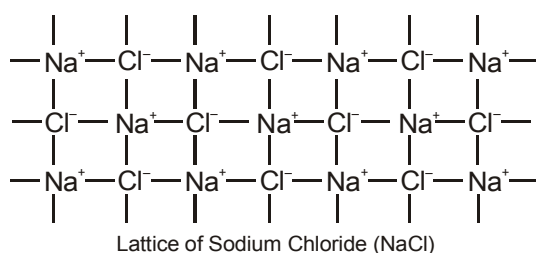
Non-polar solvents like benzene (C_6H_6) and carbon tetrachloride (CCl_4) does not solvate the ions as their dielectric constant is very low and thus they does not dissolved in ionic compounds.

Ionic compounds like sulphate and phosphate of barium and strontium are insoluble in water. This can be attributed to the high lattice energies of these compounds due to polyvalent nature (high charges) of both the cations and anions. In these cases solvation energy is not sufficient to break the crystal lattice in these compounds.



Ex.10 Why are ionic compound solids have high density and high melting point ?

Sol. An ionic compounds is formed when a positively charged ion attracts a negatively charged ion. It does not ends with the attraction of a pair of oppositely charged particles, but a positively charged particle/ion can attracts as many negative charges as it can. Likewise a negatively charged ion attracts positively charged ion. The result is that positively and negatively charged ions are systematically arranged in three dimensions so that the final material has no nett charge. Such a regular arrangement is called **lattice**.



It is seen from the figure given below that the oppositely charged ions are arranged in a particular pattern. The arrangement of sodium chloride lattice is such that each Na^+ ion is surrounded by six Cl^- ions and each Cl^- ion is surrounded by six Na^+ ions



This kind of an arrangement is called electrovalent compounds due to which they have high density and high melting point.

Ex.11 How is an ore different from a mineral ?

Sol. The metals found in nature in combined state are called minerals. The minerals from which the metals can be profitably and economically extracted is called **ore**.

Ex.12 Discuss with examples the various types of ores from which metals are extracted ?

Sol. Ores are classified into the following types :

- (i) **Native ores.** Silver, gold, platinum etc. are found in native state in the earth's crust.
- (ii) **Oxide ores.** An ore in which a metal occurs as an oxide is called an oxide ore. For example bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), haematite (Fe_2O_3) ; pyrolusite (MnO_2)
- (iii) **Sulphide ores.** An ore in which a metal occurs as sulphide is called a sulphide ore. For example, Iron pyrites (FeS), Galena (PbS), Copper pyrites (CuFeS_2), Cinnabar (HgS).
- (iv) **Carbonate ores.** An ore in which a metal occurs as carbonate or basic carbonate is called a carbonate ore. For example, limestone (CaCO_3), dolomite ($\text{CaCO}_3, \text{MgCO}_3$)
- (v) **Halide ores.** Aluminium occurs as a fluoride, e.g., cryolite (Na_3AlF_6), Sodium and potassium occur as chloride, e.g., carnallite ($\text{KCl}, \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$), rocks salt (NaCl).
- (vi) **Sulphate ores.** Barium and lead occur as barytes (BaSO_4) and anglesite (PbSO_4) respectively



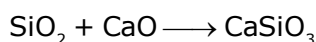
Ex.13 What do you understand by the following terms :

- (i) acidic flux (ii) basic flux (iii) slag.

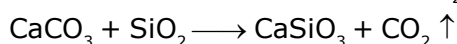
Or

What is the differences between flux and slag ?

Sol. (i) **Acidic flux.** SiO_2 is an acidic flux. It is used to remove basic impurities such as lime (CaO) from the ore.



(ii) **Basic flux.** Limestone (CaCO_3) and magnesite (MgCO_3) are examples of basic flux. These can be used to remove acidic impurities such as SiO_2 .



(iii) **Slag.** Some substances when heated with the ore combine with the earthy impurities and form easily fusible mass. The easily fusible mass is called slag which is lighter than molten metal and can be removed from the surface of the molten metal.

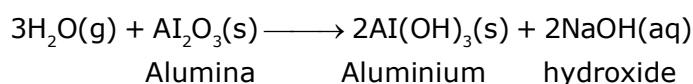
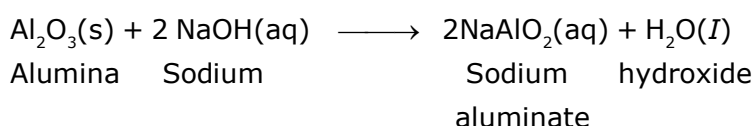
Ex.14 Give a chemical method of separating impurities from ores.

Or

Explain the term *Leaching* giving an example.

Sol. The chemical method of concentrating an ore is called leaching. It is a process in which soluble components of the ore are washed or extracted from insoluble materials by treating it with a chemical.

Example : naturally occurring ore is aluminium bauxites ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) contains ferric oxide, silica and titanium dioxide as impurities. The powdered ore is digested with caustic soda solution (NaOH) under pressure for several hours. Aluminium oxide dissolves as aluminate while impurities are unaffected and remain as suspended material which are removed by filtration. The solution containing aluminium is diluted and agitated whereby aluminium is precipitated as aluminium hydroxide which is then heated to get pure alumina.



Ex.15 Why is extraction of metal always a reduction process ?

Sol. Because a metal in the combined state has positive valency and a positive ion gets converted into atom or metal on addition of electron(s). Thus, by definition it is a reduction process.



Ex.16 Distinguish between alloy and amalgam ?

Sol. An alloy is a homogeneous solid solution of a metal with other metals or non-metals, with essentially metallic properties.

An amalgam is an alloy of a metal with the mercury.

Ex.17 What is corrosion. Explain giving an example.

Sol. When the surface of a metal is attacked by air, water and some other substance, it is said to corrode. The phenomenon is known as **corrosion**.

When iron is exposed to moist air for a long time, its surface acquires a coating of a brown, flaky substance. The brown surface easily peel off the iron surface, which if exposed further to moist air again acquires more brown layer. This is due to corrosion of iron in moist air. The flaky substance formed is called rust. Rust is mainly hydrated ferric oxide, $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$.

Another, example of copper metal. The surface of copper in moist air acquires a green coating of basic copper carbonate, $\text{Cu}(\text{OH})_2 \cdot \text{CuCO}_3$.



Ex.18 Explain the meaning of malleable and ductile.

Sol. Malleable means that metals can be beaten into thin sheets with a hammer (with out breaking). For example, if we take a piece of Al metal and beat it with a hammer four or five times, we will find that the piece of Al metal turns into a thin Aluminium sheet, without breaking. Ductile means that metals can be drawn (or stretched) into thin wire. For example, gold is the most ductile metal. Just 1 gm of Gold (Au) can be drawn into a very thin wire about 2 kilometres long.

Ex.19 Why is titanium called a strategic metal? Mention two of its properties which make it so special.

Sol. Titanium is called strategic metal because it is used for making certain war equipments. The properties which make the metal so special are:

- (i) It is light in weight but at the same time stronger than the other metals.
- (ii) it is not affected by corrosion even if kept in the open for a very long time.

Ex.20 An athlete won a bronze medal in a race competition. After some days, he found that the medal had lost its lustre due to the formation of a greenish layer on it. Name the metals present in the medal. What is the reason for the appearance of a greenish layer on its surface?

Sol. The bronze medal is an alloy and the constituting metals are copper and tin. The loss of lustre by the medal is due to the formation of a coating of green layer. This layer is of basic copper carbonate.

Ex.21 Arrange the following metals in decreasing order of their reactivity:

- (i) Cu, Ca, Mg, Na, Zn.
- (ii) Which metal listed in (i) is most likely to occur in the native state ?

Sol. (i) Based on the activity series, the decreasing order of reactivity of metals is:



- (ii) Copper is most likely to occur in the native (or free) state to a very small extent.

Ex.22 Give reasons of the following:

For making gold ornaments, 22-carat gold is generally preferred to 24-carat gold

Sol. 24-carat gold is quite pure and is very soft. As such, it can not be used for making gold ornaments. 22-carat gold is an alloy of gold containing a small amount of copper or silver. It is hard and more ductile as compared to pure gold. The ornaments are generally made from 22-carat gold.

Ex.23 (a) Are all pure liquids bad conductors of electricity?

(b) Name a liquid which is a good conductor of electricity but does not undergo electrolysis on passing electric current.

(c) If pure water is used, no electrolysis takes place. Why?

(d) Name one practical application based on the phenomenon of electrolysis.

Sol. (a) No, there are exceptions also. Mercury in pure state is a good conductor of electricity.

(b) Mercury is a good conductor of electricity but does not undergo electrolysis.

(c) Pure water (H_2O) does not dissociate itself on passing electric current.

(d) The process of electroplating on the surface of metals is based on the phenomenon of electrolysis.

Ex.24 (a) Why are ionic compounds usually hard?

(b) Why ionic compounds in the solid state do not conduct electricity and do the same in the molten state?

Sol. (a) Ionic compounds are very closely packed in space. As a result, the vacant spaces or sites are quite less and the attractive forces among the ions are very strong. They are therefore, generally hard.

(b) The conductivity of ionic compound is due to the momentum or mobility of the ions that are present. For example, the electrical conductivity of sodium chloride ($\text{Na}^+ \text{Cl}^-$) is due to the mobility of the ions present. Since the ions can move only in the molten state and not in the solid state, these compounds are conducting only in the molten state.

Ex.25 Alloys are used in electrically heating devices rather than pure metals. Give one reason.

Ans. Alloys are generally the combination of two or more metals. Since metals are good conductors of electricity, a combination of metals i.e. alloy is expected to be a better conductor of electricity than the pure metal.



NCERT QUESTIONS WITH SOLUTIONS

- Q.1** Give an example of a metal which
- is a liquid at room temperature.
 - can be easily cut with a knife.
 - is the best conductor of heat.
 - is a poor conductor of heat.

Ans. (i) Metal that exists in liquid state at room temperature -Mercury
 (ii) Metal that can be easily cut with a knife -Sodium
 (iii) Metal that is the best conductor of heat -Silver
 (iv) Metals that are poor conductors of heat Mercury and lead.

- Q.2** Explain the meanings of malleable and ductile.

Ans. Malleable: Substances that can be beaten into thin sheets are called malleable. For example, most of the metals are malleable.

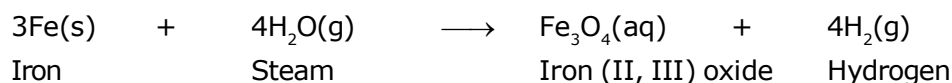
Ductile: Substances that can be drawn into thin wires are called ductile. For example, most of the metals are ductile.

- Q.3** Why sodium is kept immersed in kerosene oil ?

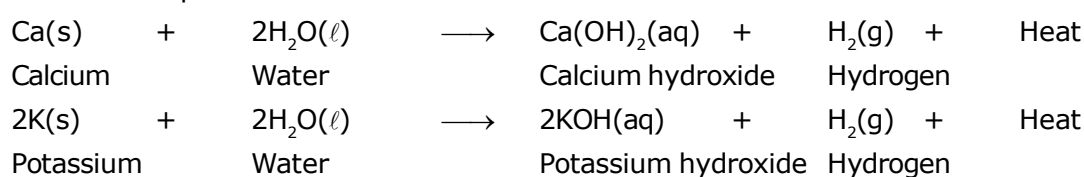
Ans. Sodium and potassium are very reactive metals and combine explosively with air as well as water. Hence, they catch fire if kept in open. Therefore, to prevent accidental fires and accidents, sodium is stored immersed in kerosene oil.

- Q.4** Write equations for the reactions of

- (i) Iron with steam



- (ii) Calcium and potassium with water



- Q.5** Samples of four metals A, B, C and D were taken and added to the following solutions one by one. The results obtained have been tabulated as follows.

Metal	FeSO ₄	CuSO ₄	ZnSO ₄	AgNO ₃
A.	N.R.	Dis.	–	–
B.	Dis.	–	N.R.	–
C.	N.R.	N.R.	N.R.	Dis.
D.	N.R.	N.R.	N.R.	N.R.

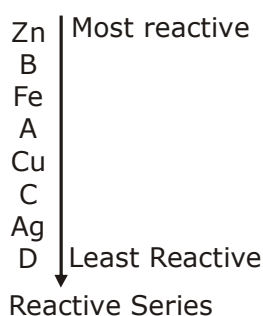
Here N.R. = No reaction, Dis. = Displacement Use the above table to answer the following questions about metals A, B, C and D.

- Which is the most reactive metal?
- What would you observe if B is added to a solution of copper (II) sulphate?
- Arrange the metals A, B, C and D in the order of decreasing reactivity.



Ans. $A + \text{FeSO}_4 \longrightarrow$ No reaction, i.e., A is less reactive than iron
 $A + \text{CuSO}_4 \longrightarrow$ Displacement, i.e., A is more reactive than copper
 $B + \text{FeSO}_4 \longrightarrow$ Displacement, i.e., B is more reactive than iron
 $B + \text{ZnSO}_4 \longrightarrow$ No reaction, i.e., B is less reactive than zinc
 $C + \text{CuSO}_4 \longrightarrow$ No reaction, i.e., C is less reactive than iron
 $C + \text{ZnSO}_4 \longrightarrow$ No reaction, i.e., C is less reactive than zinc
 $C + \text{AgNO}_3 \longrightarrow$ Displacement, i.e., C is more reactive than silver
 $D + \text{FeSO}_4/\text{CuSO}_4/\text{ZnSO}_4/\text{AgNO}_3 \longrightarrow$ No reaction, i.e., D is less reactive than iron, copper, zinc and silver.

From the above equations, we obtain:



- (i) B is the most reactive metal.
(ii) If B is added to a solution of copper (II) sulphate, then it would displace copper.
 $B + \text{CuSO}_4 \longrightarrow$ Displacement
(iii) The arrangement of the metals in the order of decreasing reactivity is:
 $B > A > C > D$

Q.6 Which gas is produced when dilute hydrochloric acid is added to a reactive metal? Write the chemical reaction when iron reacts with dilute H_2SO_4 .

Ans. Hydrogen gas is evolved when dilute hydrochloric acid is added to a reactive metal.
When iron reacts with dilute H_2SO_4 , iron (II) sulphate with the evolution of hydrogen gas is formed.
 $\text{Fe(s)} + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{FeSO}_4(\text{aq}) + \text{H}_2(\text{g})$

Q.7 What would you observe when zinc is added to a solution of iron (II) sulphate? Write the chemical reaction that takes place.

Ans. Zinc is more reactive than iron. Therefore, if zinc is added to a solution of iron (II) sulphate, then It would displace iron from the solution.
 $\text{Zn(s)} + \text{FeSO}_4(\text{aq}) \longrightarrow \text{ZnSO}_4(\text{aq}) + \text{Fe(s)}$

Q.8 (i) Write the electron-dot structures for sodium, oxygen and magnesium.
(ii) Show the formation of Na_2O and MgO by the transfer of electrons.
(iii) What are the ions present in these compounds?

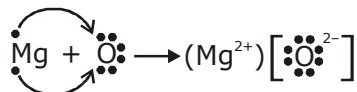
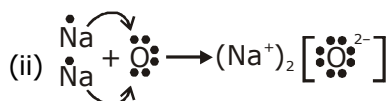
Ans. (i) The representation of elements with valence electrons as dots around the elements is referred to as electron-dot structure for elements.

(a) Sodium (2, 8, 1) = Na

(b) Oxygen (2, 6) = O



(c) Magnesium (2, 8, 2) = $\ddot{\text{Mg}}$



(iii) The ions present in Na_2O are Na^+ and O^{2-} ions and in MgO are Mg^{2+} and O^{2-} ions.

Q.9 Why do ionic compounds have high melting points?

Ans. Ionic compounds have strong electrostatic forces of attraction between the ions. Therefore, it requires a lot of energy to overcome these forces. That is why ionic compounds have high melting points.

Q.10 Define the following terms.

(i) Mineral (ii) Ore (iii) Gangue

Ans. (i) Mineral: Most of the elements occur in nature in combined state as minerals. The chemical composition of minerals is fixed.

(ii) Ore : Minerals from which metals can be extracted profitably are known as ores.

(iii) Gangue: The impurities (sand, silt, soil, gravel, etc.) present in the ore are called gangue.

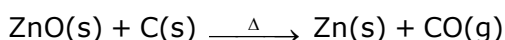
Q.11 Name two metals which are found in nature in the free state.

Ans. The metals at the bottom of the reactivity series are mostly found in free state. For example: gold, silver, and platinum.

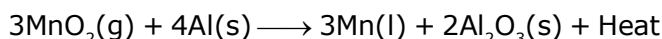
12. What chemical process is used for obtaining a metal from its oxide ?

Ans. The chemical process used for obtaining a metal from its oxide is reduction. In this process, metal oxides are reduced by using suitable reducing agents such as carbon or by using highly reactive metals to displace the metals from their oxides.

For example, zinc oxide is reduced to metallic zinc by heating with carbon.



Manganese dioxide is reduced to manganese by treating it with aluminium powder. In this case, aluminium displaces manganese from its oxide.



Oxides of more reactive metals are reduced by electrolysis.

Q.13 Metallic oxides of zinc, magnesium and copper were heated with the following metals.

Metal	Zinc	Magnesium	Copper
Zinc oxide	–	–	–
magnesium oxide	–	–	–
Copper oxide	–	–	–

In which cases will you find displacement reactions taking place?



	Metal	Zinc	Magnesium	Copper
Ans.	Zinc oxide	N.R.	Dis.	N.R.
	magnesium oxide	N.R.	N.R.	N.R.
	Copper oxide	Dis.	Dis.	N.R.

Here N.R. = No reaction, Dis. = Displacement.

Q.15 Which metals do not corrode easily?

Ans. More reactive a metal is, more likely it is to be corroded. Therefore, less reactive metals are less likely to get corroded. This is why gold plating provides high resistance to corrosion.

Q.16 What are alloys?

Ans. Alloys are homogeneous mixtures of two or more elements. The elements could be two metals, or a metal and a non-metal. Any alloy is formed by first melting the metal and then dissolving the other elements in it. For example, steel is an alloy of iron and carbon.

Q.17 Which of the following pairs will give displacement reactions?

- (a) NaCl solution and copper metal
- (b) MgCl_2 solution and aluminium metal
- (c) FeSO_4 solution and silver metal
- (d) AgNO_3 solution and copper metal

Ans. (d) AgNO_3 solution and copper metal

Q.18 Which of the following methods is suitable for preventing an iron frying pan from rusting?

- (a) Applying grease
- (b) Applying paint
- (c) Applying a coating of zinc
- (d) all of the above.

Ans. (c) Applying a coating of zinc. One can also apply grease and paint to prevent iron from rusting. However, in case of iron frying pan, grease and paint cannot be applied because when the pan will be heated and washed again and again, the coating of grease and paint would get destroyed.

Q.19 An element reacts with oxygen to give a compound with a high melting point. This compound is also soluble in water. The element is likely to be

- (a) Calcium
- (b) Carbon
- (c) Silicon
- (d) Iron

Ans. (a) The element is likely to be calcium

Q.20 Food cans are coated with tin and not with zinc because

- (a) zinc is costlier than tin.
- (b) zinc has a higher melting point than tin.
- (c) zinc is more reactive than tin.
- (d) zinc is less reactive than tin.

Ans. (c) Food cans are coated with tin and not with zinc because zinc is more reactive than tin.



Q.21 You are given a hammer, a battery, a bulb, wires and a switch.

(a) How could you use them to distinguish between samples of metals and non-metals?

(b) Assess the usefulness of these tests in distinguishing between metals and non-metals.

Ans. (a) With the hammer, we can beat the sample and if it can be beaten into thin sheets (that is, it is malleable), then it is a metal otherwise a non metal. Similarly, we can use the battery, bulb, wires, and a switch to set up a circuit with the sample. If the sample conducts electricity, then it is a metal otherwise a non-metal.

(b) The above tests are useful in distinguishing between metals and non-metals as these are based on the physical properties. No chemical reactions are involved in these tests.

Q.22 What are amphoteric oxides? Give two examples of amphoteric oxides.

Ans. Those oxides that behave as both acidic and basic oxides are called amphoteric oxides.

Examples: aluminium oxide (Al_2O_3), zinc oxide (ZnO)

Q.23 Name two metals which will displace hydrogen from dilute acids, and two metals which will not.

Ans. Metals that are more reactive than hydrogen displace it from dilute acids. For example: sodium and potassium. Metals that are less reactive than hydrogen do not displace it. For example: copper and silver.

Q.24 In the electrolytic refining of a metal M. what would you take as the anode, the cathode and the electrolyte ?

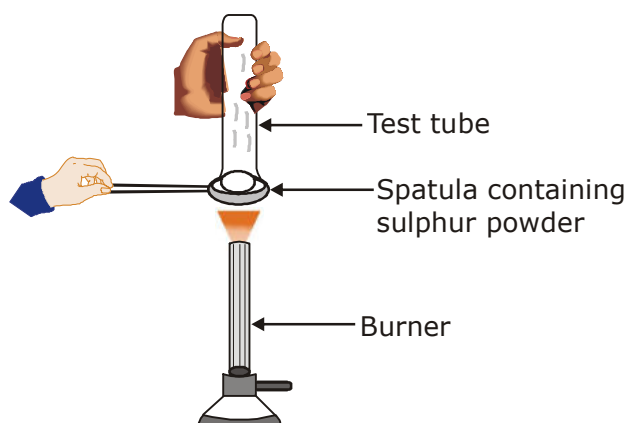
In the electrolytic refining of a metal M:

Ans. Anode -Impure metal M

Cathode -Thin strip of pure metal M

Electrolyte -Solution of salt of the metal M

Q.25 Pratyush took sulphur powder on a spatula and heated it. He collected the gas evolved by inverting a test tube over it, as shown in figure below.



Collection of Gas

(a) What will be the action of gas on

(i) dry litmus paper?

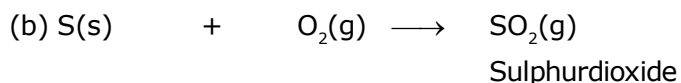
(ii) moist litmus paper?

(b) Write a balanced chemical equation for the reaction taking place.



Ans. (a) (i) There will be no action on dry litmus paper.

(ii) Since the gas is sulphur dioxide (SO_2), it turns moist blue litmus paper to red because sulphur dioxide reacts with moisture to form sulphurous acid.



Q.26 State two ways to prevent the rusting of iron. Two ways to prevent the rusting of iron are:

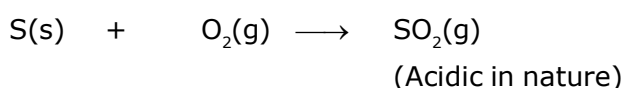
Ans. (i) Oiling, greasing, or painting: By applying oil, grease, or paint, the surface becomes water proof and the moisture and oxygen present in the air cannot come into direct contact with iron. Hence, rusting is prevented.

(ii) Galvanisation : An iron article is coated with a layer of zinc metal, which prevents the iron to come in contact with oxygen and moisture. Hence, rusting is prevented.

Q.27 What type of oxides is formed when non-metals combine with oxygen?

Ans. Non-metals combine with oxygen to form acidic oxides.

For examples:



Q.28 Give reasons.

(a) Platinum, gold and silver are used to make jewellery.

(b) Sodium, potassium and lithium are stored under oil.

(c) Aluminium is a highly reactive metal, yet it is used to make utensils for cooking.

(d) Carbonate and sulphide ores are usually converted into oxides during the process of extraction.

Ans. (a) Platinum, gold, and silver are used to make jewellery because they are very lustrous. Also, they are very less reactive and do not corrode easily.

(b) Sodium, potassium, and lithium are very reactive metals and react very vigorously with air as well as water. Therefore, they are kept immersed in kerosene oil in order to prevent their contact with air and moisture.

(c) Though aluminium is a highly reactive metal, it is resistant to corrosion. This is because aluminium reacts with oxygen present in air to form a thin layer of aluminium oxide. This oxide layer is very stable and prevents further reaction of aluminium with oxygen. Also, it is light in weight and a good conductor of heat. Hence, it is used to make cooking utensils.

(d) Carbonate and sulphide ores are usually converted into oxides during the process of extraction because metals can be easily extracted from their oxides rather than from their carbonates and sulphides.

Q.29 You must have seen tarnished copper vessels being cleaned with lemon or tamarind juice. Explain why these sour substances are effective in cleaning the vessels.

Ans. Copper reacts with moist carbon dioxide in air to form copper carbonate and as a result, copper vessel loses its shiny brown surface forming a green layer of copper carbonate. The citric acid present in the lemon or tamarind neutralises the basic copper carbonate and dissolves the layer. That is why, tarnished copper vessels are cleaned with lemon or tamarind juice to give the surface of the copper vessel its characteristic lustre.



Q.30 Differentiate between metal and non-metal on the basis of their chemical properties.

Ans. Metals:

- (i) Metals are electropositive.
- (ii) They react with oxygen to form basic oxides.
- (iii) These have ionic bonds.
- (iv) They react with water to form oxides and hydroxides. Some metals react with cold water, some with hot water, and some with steam.
- (v) They react with dilute acids to form a salt and evolve hydrogen gas. However, Cu, Ag, Au, Pt, Hg do not react.
- (vi) They react with the salt solution of metals. Depending on their reactivity, displacement, reaction can occur.
- (vii) These act as oxidising agents (as they can gain electrons).

Non-metals:

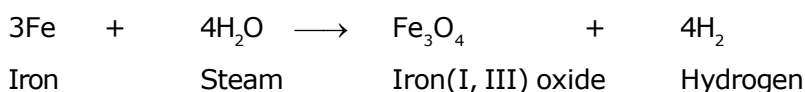
- (i) Non-metals are electronegative.
- (ii) They react with oxygen to form acidic or neutral oxides.
- (iii) These have covalent bonds.
- (iv) They do not react with water.
- (v) They do not react with dilute acids. These are not capable of replacing hydrogen.
- (vi) These react with the salt solution of non-metals.
- (vii) They act as reducing agents (as they can easily lose electrons).

Q.31 A man went door to door posing as a goldsmith, He promised to bring back the glitter of old and dull gold ornaments. An unsuspecting lady gave a set of gold bangles to him which he dipped in a particular solution, The bangles sparkled like new but their weight was reduced drastically. The lady was upset but after a futile argument the man beat a hasty retreat. Can you play the detective to find out the nature of the solution he had used?

Ans. He must have dipped the gold metal in the solution of aqua regia - a 3:1 mixture of conc. HCl and conc. HNO_3 . Aqua regia is a fuming, highly corrosive liquid. It dissolves gold in it. After dipping the gold ornaments in aqua regia, the outer layer of gold gets dissolved and the inner shiny layer appears. That is why the weight of gold ornament reduced.

Q.32 Give reasons why copper is used to make hot water tanks and not steel (an alloy of iron).

Ans. Copper does not react with cold water, hot water, or steam. However, iron reacts with steam. If the hot water tanks are made of steel (an alloy of iron), then iron would react vigorously with the steam formed from hot water.



That is why copper is used to make hot water tanks, and not steel.



EXERCISE – I

BOARD PROBLEMS

- Q.1** Define metals.
- Q.2** Name a metal which can be cut with knife.
- Q.3** Name two metals which does not react with oxygen.
- Q.4** What type of oxides are formed when metals combine with oxygen.
- Q.5** Name two metals which are found in nature in free state.
- Q.6** Give electron dot structure of chlorine and oxygen.
- Q.7** Explain why the surfaces of some metals acquire dull appearance when exposed to air for long period of time.
- Q.8** State two ways to prevent rusting of iron.
- Q.9** What are amphoteric oxides? Give two examples of amphoteric oxides?
- Q.10** Define alloy. Give two advantage of making alloys.
- Q.11** Give three difference between metals and non-metals based on physical properties.
- Q.12** Give reasons.
1. Aluminium oxide is amphoteric oxide
 2. Non-metals does not conduct electricity
 3. Metals displace hydrogen gas from acids
- Q.13** Explain why?
- (a) Iron articles are frequently painted
 - (b) Iron sheets are coated with zinc layer.
- Q.14** What is activity series of metals, Arrange the given metals in activity series: Fe, Au, Zn, Al, Cu.
- Q.15** What determines the reactivity of metals ?
- Q.16** What happen when :
- (i) Lead is heated to 400°C–500°C in air.
 - (ii) Steam is passed over heated iron.
 - (iii) Copper oxide is heated with magnesium.
 - (iv) Aluminium wire is dipped in heating water.
- Q.17** How would you show that silver is chemically less reactive than copper ?
- Q.18** Name two metals which may occur as sulphides.
- Q.19** Name a metal which occurs as fluoride.
- Q.20** Name two metals which may occur as carbonates.
- Q.21** Identify the most reactive and the least reactive metal amongst the following :
- Al, K, Cu, Au
- Q.22** An oxide ore has been found to contain some impurities which are magnetic. State the process to concentrate this ore.
- Q.23** For reduction of metallic oxide (M_2O_3) suggest a reducing agent cheaper than aluminium ?
- Q.24** Name the process in relation to metallurgy whereby an ore is heated strongly in absence of air.



- Q.25** Name the process in relation to metallurgy whereby an ore is heated in excess of air or oxygen.
- Q.26** What types of ores are treated in 'calcination'?
- Q.27** A light and strong alloy is needed for making instruments. What metal should be added to a small amount of magnesium to obtain the alloy?
- Q.28** Give reason why copper is used to make hot water tanks but steel (an alloy of iron) is not.
- Q.29** Name an ore of zinc other than zinc oxide. By what process can this ore be converted to zinc oxide ?
- Q.30** Select the metalloids/ from amongst the following elements.
- (i) Bismuth (ii) Copper
(iii) Zinc (iv) Iron
- Q.31** What type of reaction is involved in rusting ?
- Q.32** From amongst the metals sodium, calcium, aluminium, copper and magnesium, name the metal
- (i) which reacts with water only on boiling and
(ii) another which does not react even with steam.
- Q.33** An element reacts with oxygen to form an oxide which dissolves in dilute hydrochloric acid. The oxide also turns a solution of red litmus blue. Is the element a metal or a non-metal ? Explain with the help of a suitable example.
- Q.34** Choose the metal (from the list given below) which can displace zinc from zinc sulphate solution. Lead, Copper, Magnesium, Silver. Write the equation of the chemical reaction involved.
- Q.35** Explain why sodium is not found in the native state.



EXERCISE – II
OLYMPIAD QUESTIONS

- Q.1** Which is the least conductor of heat –
 (A) Gold (B) Platinum
 (C) Silver (D) Lead
- Q.2** Metal haveno. of electrons in their outer most shell –
 (A) 1 to 8 (B) 7 to 9
 (C) 1 to 3 (D) 10 to 12
- Q.3** Which oxide is neutral ?
 (A) NO_2 (B) MgO
 (C) H_2O (D) None of these
- Q.4** $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ is the chemical formula of–
 (A) Bauxite (B) Haemetite
 (C) China Clay (D) Monazite
- Q.5** An alloy is –
 (A) A element (B) A mixture
 (C) An isomer (D) A metalloid
- Q.6** Which non-metal is the best conductor of electricity –
 (A) Phosphorus (B) Fluorine
 (C) Graphite (D) Bromine
- Q.7** Which compound is used in photography –
 (A) AgNO_3 (B) AgO
 (C) AgBr (D) AgCl
- Q.8** Carnallite is the mineral of –
 (A) Na (B) Ca
 (C) Mg (D) All of these
- Q.9** The magnesium is used in –
 (A) Flash bulb (B) Grignard reagent
 (C) Electron alloy (D) All of these
- Q.10** Cinnabar is an ore of –
 (A) Mercury (B) Copper
 (C) Calcium (D) Lead
- Q.11** The constituent of haemoglobin is –
 (A) Iron (B) Sodium
 (C) Copper (D) Magnesium
- Q.12** The most abundant metal in the earth crust is –
 (A) Al (B) Fe
 (C) O (D) Cu
- Q.13** Because of high electropositively, the atom of metals can easily form –
 (A) Positive ions (B) Negatively ions
 (C) Neutral ions (D) Covalent bonds
- Q.14** Volatile metals are purified by –
 (A) Oxidation (B) Distillation
 (C) Liquation (D) Electrolytic refining
- Q.15** Amalgam is the homogeneous mixture of –
 (A) Metal and metal
 (B) Metal and mercury
 (C) Metal and non-metal
 (D) All of these
- Q.16** Which of the following is a ferrous alloy–
 (A) Solder (B) Brass
 (C) Magnalium (D) Steel



- Q.17** Which of the following statements is correct—
 (A) All minerals are ores
 (B) All ores are minerals
 (C) Some ores are minerals
 (D) None is correct
- Q.18** Food cans are coated with tin and not zinc because –
 (A) Zinc is costlier than tin
 (B) Zinc has a higher melting point than tin
 (C) Zinc is more reactive than tin
 (D) Zinc is less reactive than tin
- Q.19** Elements with atomic number greater than 92 are also called _____. **[NTSE]**
 (A) alkali metals
 (B) alkaline earth metals
 (C) transuranic elements
 (D) noble gas elements
- Q.20** A purple-coloured solid halogen is _____. **[NTSE]**
 (A) Cl (B) Br
 (C) I (D) F
- Q.21** Chalcogen refers to _____. **[NTSE]**
 (A) alkali-forming elements
 (B) salt-forming elements
 (C) ore-forming elements
 (D) chemically inert elements
- Q.22** Which of the following is a solid at STP? **[NTSE]**
 (A) fluorine (B) chlorine
 (C) bromine (D) iodine
- Q.23** Element M is a metal and its chloride has the formula MCl_2 . The element most likely belongs to which group of the periodic table? **[NTSE]**
 (A) 1 (B) 2
 (C) 15 (D) 17
- Q.24** Copper is extracted from low grade ore by _____. **[NTSE]**
 (A) hydrometallurgy
 (B) pyrometallurgy
 (C) electrometallurgy
 (D) all of the above processes
- Q.25** Roasting process is applied to which of the following ores? **[NTSE]**
 (A) galena (B) iron pyrites
 (C) copper glance (D) all of these
- Q.26** Purification of metals by liquation method is based on difference in _____. **[NTSE]**
 (A) density (B) melting point
 (C) solubility (D) vapour density
- Q.27** Arrange the following metal in the increasing order of their reactivity towards water: Zinc, Iron, Magnesium, Sodium. **[NTSE]**
 (A) iron < Magnesium < sodium < zinc
 (B) iron < zinc < magnesium < sodium
 (C) magnesium < iron < sodium < zinc
 (D) sodium < iron < magnesium < zinc



- Q.28** Which of the following is used for making magnets? **[NTSE]**
 (A) duralumin (B) magnalium
 (C) bronze (D) alnico
- Q.29** White phosphorus is stored in **[NTSE]**
 (A) ether (B) water
 (C) alcohol (D) kerosene oil
- Q.30** Ordinary glass is a mixture of **[NTSE]**
 (A) sodium silicate, calcium silicate
 (B) sodium silicate, calcium silicate and silica
 (C) sodium silicate and silica
 (D) none of the above
- Q.31** Annealing is done to **[NTSE]**
 (A) increase brittleness
 (B) increase Transparency
 (C) decrease brittleness
 (D) increase refractive index
- Q.32** Polymer used in making floor tiles is **[NTSE]**
 (A) teflon (B) polypropylene
 (C) polyvinyl chloride (D) buta-1, 3-diene
- Q.33** Which of the following is an example of condensation polymers? **[NTSE]**
 (A) polyethene (B) neoprene
 (C) teflon (D) nylon
- Q.34** Insulation of electric wire is done by **[NTSE]**
 (A) isoprene (B) neoprene
 (C) vinyl chloride (D) buta-1, 3-diene
- Q.35** Permanent magnets can be made from **[NTSE]**
 (A) Ni steel (B) Cobalt steel
 (C) Stainless steel (D) Wrought iron
- Q.36** The formula of Oleum is **[NTSE]**
 (A) H_2SO_4 (B) $\text{H}_2\text{S}_2\text{O}_7$
 (C) $\text{H}_2\text{S}_2\text{O}_3$ (D) $\text{H}_2\text{S}_2\text{O}_6$
- Q.37** The main constituents of cement are: **[NTSE]**
 (A) calcium oxide, silicon dioxide, Aluminium oxide
 (B) calcium oxide, Iron oxide, Sulphur dioxide
 (C) magnesium oxide, Silicon dioxide, Aluminium oxide
 (D) none of these
- Q.38** Hard glass is prepared by **[NTSE]**
 (A) fusing a mixture of sodium carbonate, calcium carbonate and silica
 (B) fusing a mixture of potassium carbonate, calcium carbonate and silica
 (C) fusing a mixture of potassium carbonate and any oxide
 (D) none of the above
- Q.39** The soap can be hardened by **[NTSE]**
 (A) adding sodium carbonate or sodium silicate during its manufacture
 (B) adding sodium chloride
 (C) adding potassium hydroxide
 (D) adding animal fat and coconut oil
- Q.40** Soda Acid for extinguisher contains **[NTSE]**
 (A) sodium carbonate and nitric acid
 (B) sodium hydrogen carbonate and sulphuric acid
 (C) sodium carbonate and carbonic acid
 (D) sodium chloride and sulphuric acid



Q.41 The real bleaching agent present in bleaching powder is
[NTSE]

- (A) chlorine
(B) oxygen
(C) CaO
(D) none of the above

Q.42 Cake does not taste bitter due to presence of
[NTSE]

- (A) sodium carbonate
(B) tartaric acid
(C) citric acid
(D) sugar

Q.43 What is obtained on adding lime to H_2O ?

[NTSE]

- (A) lime
(B) limestone
(C) slaked lime
(D) quicklime

ANSWER KEY

- | | | | | | | | |
|------------|---|------------|---|------------|---|------------|---|
| 1. | D | 2. | C | 3. | C | 4. | C |
| 5. | B | 6. | C | 7. | C | 8. | C |
| 9. | D | 10. | A | 11. | A | 12. | A |
| 13. | A | 14. | B | 15. | B | 16. | D |
| 17. | A | 18. | C | 19. | C | 20. | C |
| 21. | C | 22. | D | 23. | B | 24. | A |
| 25. | D | 26. | B | 27. | B | 28. | D |
| 29. | B | 30. | A | 31. | C | 32. | C |
| 33. | D | 34. | C | 35. | D | 36. | B |
| 37. | A | 38. | B | 39. | A | 40. | B |
| 41. | A | 42. | B | 43. | C | | |



EXERCISE – II
OLYMPIAD QUESTIONS

1. Which of the following properties is not associated with metals?
(A) Allotropy (B) Conductivity
(C) Ductility (D) Malleability
2. Which of the following elements is a metal?
(A) Aluminium (B) Boron
(C) Carbon (D) Silicon
3. Which of the following elements is not a metal?
(A) Calcium (B) Copper
(C) Potassium (D) Sulphur
4. Which of the following elements is a metalloid?
(A) Carbon (B) Arsenic
(C) Beryllium (D) Sulphur
5. Iron is a/an :
(A) Alloy (B) Metal
(C) Metalloid (D) Nonmetal
6. Graphite is a/an :
(A) Alloy (B) Metal
(C) Metalloid (D) Nonmetal
7. Stainless steel is a/an :
(A) Alloy (B) Metal
(C) Metalloid (D) Nonmetal
8. Which of the following nonmetals is a good conductor of electricity?
(A) Diamond (B) Graphite
(C) Phosphorus (D) Sulphur
9. The reactivities of iron, magnesium, sodium and zinc towards water are in the following order:
(A) $\text{Fe} > \text{Mg} > \text{Na} > \text{Zn}$ (B) $\text{Zn} > \text{Na} > \text{Mg} > \text{Fe}$
(C) $\text{Na} > \text{Mg} > \text{Zn} > \text{Fe}$ (D) $\text{Mg} > \text{Na} > \text{Fe} > \text{Zn}$
10. Hydrogen is not a metal but it has been included in the reactivity series because it :
(A) Forms positive ions like metals
(B) Is a diatomic
(C) Is the first element of the periodic table
(D) Reacts with metals
11. Which of the following metals constitutes the alloy magnalium?
(A) Al, Cu (B) Al, Fe
(C) Ag, Mg (D) Al, Mn
12. One of the constituents of amalgam is :
(A) Aluminium (B) Copper
(C) Iron (D) Mercury
13. Which of the following metals reacts with water causing fire?
(A) Aluminium (B) Calcium
(C) Sodium (D) Zinc
14. Which of the following metals is used in storage battery?
(A) Iron (B) Lead
(C) Tin (D) Zinc
15. Which of the following alloys does not contain copper?
(A) Bell metal (B) Brass
(C) Bronze (D) Solder
16. Which of the following metals reacts with water/steam to produce oxide instead of hydroxide?
(A) Sodium (B) Potassium
(C) Calcium (D) Magnesium
17. Which of the following metals does not react with dilute hydrochloric acid producing hydrogen gas?
(A) Zinc (B) Tin
(C) Lead (D) Copper
18. Which of the following alloys does not contain tin?
(A) Bronze (B) Gun metal
(C) German silver (D) Type metal
19. The metal which exists as a liquid is :
(A) Aluminium (B) Sodium
(C) Mercury (D) Potassium
20. Which of the following nonmetals exists in the liquid form?
(A) Chlorine (B) Bromine
(C) Iodine (D) Fluorine
21. Which of the following nonmetals exists in the solid phase?
(A) Fluorine (B) Chlorine
(C) Bromine (D) Iodine
22. Nonmetals do not conduct electricity. However an allotrope of a nonmetal is used as electrode. It is :
(A) Diamond (B) Graphite
(C) Sulphur (D) Phosphorus
23. The hardest nonmetal amongst sulphur, graphite, diamond and silicon is :
(A) Sulphur (B) Graphite
(C) Diamond (D) Silicon
24. Which of the following nonmetals sublimes on heating?



- (A) Fluorine (B) Chlorine
(C) Bromine (D) Iodine
- 25.** Which of the following elements produces acidic oxide on reacting with oxygen?
(A) Sodium (B) Chlorine
(C) Magnesium (D) Zinc
- 26.** Which of the following elements produces basic oxide on reacting with oxygen?
(A) Chlorine (B) Sulphur
(C) Phosphorus (D) Magnesium
- 27.** Which of the following replacement reactions is not possible?
(A) $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$
(B) $2\text{Ag} + \text{CuSO}_4 \rightarrow \text{Ag}_2\text{SO}_4 + \text{Cu}$
(C) $\text{Mg} + \text{CuSO}_4 \rightarrow \text{MgSO}_4 + \text{Cu}$
(D) $2\text{Na} + \text{CuSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{Cu}$
- 28.** Copper sulphate solution can be safely kept in a container made of :
(A) Aluminium (B) Lead
(C) Silver (D) Zinc
- 29.** Most metals can be drawn into thin wires. This property is known as :
(A) Allotropy (B) Conductivity
(C) Ductility (D) Malleability
- 30.** Most metals can be drawn into sheets. This property is known as :
(A) Allotropy (B) Conductivity
(C) Ductility (D) Malleability
- 31.** Which of the following oxides is neither acidic nor basic?
(A) CO_2 (B) N_2O
(C) SO_2 (D) SO_3
- 32.** Which of the following oxides may be said to be neutral oxide?
(A) CO (B) CO_2
(C) SO_2 (D) SO_3
- 33.** Which of the following elements does not react with cold acids?
(A) Na (B) Mg
(C) C (D) Zn
- 34.** Which of the following elements would produce covalent hydride?
(A) Na (B) Mg
(C) Cl (D) K
- 35.** Which of the following nonmetal is used in polymers?
(A) Nitrogen (B) Phosphorus
(C) Silicon (D) Sulphur
- 36.** The second most abundant element in the earth's crust is :
(A) Oxygen (B) Silicon
(C) Aluminium (D) Iron
- 37.** The first most abundant element in the earth's crust is :
(A) Oxygen (B) Silicon
(C) Aluminium (D) Iron
- 38.** The element silicon exists as :
(A) Gas (B) Liquid
(C) Soft solid (D) Hard solid
- 39.** The element silicon exists as :
(A) Crystalline covalent solid
(B) Crystalline ionic acid
(C) Amorphous solid
(D) Liquid
- 40.** Silicon does not react with acids except
(A) Hydrochloric acid (B) Hydrobromic acid
(C) Hydroiodic acid (D) Hydrofluoric acid
- 41.** The elemental phosphorus is written as :
(A) P (B) P_2
(C) P_3 (D) P_4
- 42.** The white phosphorus is stored :
(A) In air (B) Under water
(C) Under kerosene (D) Under CS_2
- 43.** Which of the following statements is true?
(A) Both white and red phosphorus are soluble in water
(B) Both white and red phosphorus are soluble in carbon disulphide
(C) White phosphorus is soluble in carbon disulphide whereas red phosphorus is insoluble
(D) White phosphorus is insoluble in carbon disulphide whereas red phosphorus is soluble
- 44.** Which of the following statement is true?
(A) Both white and red phosphorus are reactive
(B) Both white and red phosphorus are inactive
(C) White phosphorus is reactive whereas red phosphorus is inactive
(D) White phosphorus is inactive whereas red phosphorus is reactive
- 45.** Which of the following statements about phosphorus is not true?
(A) Phosphorus does not occur in free state
(B) Phosphorus is present in bones and teeth
(C) Phosphorus exists in several allotropic forms



- (D) White phosphorus is much less active than red variety
- 46.** When phosphorus is heated with conc. HNO_3 , it reduces the acid to :
 (A) NO (B) NO_2
 (C) N_2O_3 (D) N_2O_5
- 47.** When phosphorus is heated with conc. HNO_3 , it is oxidized to :
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 48.** P_4O_6 is the anhydride of :
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 49.** P_4O_{10} is the anhydride of :
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 50.** Which of the following is orthophosphorus acid?
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 51.** Which of the following is orthophosphoric acid?
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 52.** When P_4O_6 is dissolved in cold water, we obtain :
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 53.** When P_4O_{10} is boiled with water, the final product of hydrolysis is :
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 54.** Which of the following is pyrophosphoric acid?
 (A) H_3PO_2 (B) H_3PO_3
 (C) H_3PO_4 (D) $\text{H}_4\text{P}_2\text{O}_7$
- 55.** The elemental sulphur is written as :
 (A) S (B) S_2
 (C) S_4 (D) S_8
- 56.** Which of the following statements is true?
 (A) Both rhombic and monoclinic sulphur are soluble in water
 (B) Both rhombic and monoclinic sulphur are soluble in carbon disulphide
 (C) Both rhombic and monoclinic sulphur are insoluble in carbon disulphide
 (D) Rhombic sulphur can be converted into monoclinic sulphur but the reverse is not possible
- 57.** Colloidal sulphur is obtained when :
 (A) Sulphur is heated in absence of air
 (B) Sulphur is heated in presence of air
 (C) Sodium thiosulphate is treated with iodine
 (D) H_2S is passed through water containing HNO_3
- 58.** Which of the following forms of sulphur is stable at room temperature and 1 atmospheric pressure?
 (A) Amorphous (B) Hexagonal
 (C) Monoclinic (D) Orthorhombic
- 59.** Which of the following statement is not true of sulphur?
 (A) Sulphur belongs to Group VIA of the periodic table
 (B) Sulphur exhibits allotropy
 (C) Sulphur occurs both in the native form and combined form
 (D) Sulphur is soluble in water
- 60.** Which of the following gases is used for the qualitative analysis of metal ions?
 (A) CO_2 (B) H_2S
 (C) SO_2 (D) SO_3
- 61.** Which of the following nitrogen oxide is neutral?
 (A) N_2O (B) NO_2
 (C) N_2O_3 (D) N_2O_5
- 62.** Which of the following nitrogen oxides is produced during lighting bolts in the atmosphere?
 (A) NO (B) NO_2
 (C) N_2O_3 (D) N_2O_5
- 63.** Which of the following nitrogen oxides is an anhydride of HNO_2 ?
 (A) N_2O (B) NO_2
 (C) N_2O_3 (D) N_2O_5
- 64.** Which of the following nitrogen oxides is an anhydride of HNO_3 ?
 (A) N_2O (B) NO_2
 (C) N_2O_3 (D) N_2O_5
- 65.** Nitrates of all metals are :
 (A) Coloured (B) Insoluble in water
 (C) Soluble in water (D) Unstable
- 66.** Burning sulphur in air produces :
 (A) H_2S (B) H_2S_2
 (C) SO_2 (D) SO_3
- 67.** Sulphur dioxide is a strong reducing agent. However, it can also act as an oxidizing agent. Which of the following reactions shows its oxidizing nature?
 (A) Bleaching flower petals
 (B) Decolourising of acidified KMnO_4 solution
 (C) Reaction with H_2S to give sulphur



- (D) Turning acidified dichromate paper green
- 68.** Which of the following is not true for SO_2 ?
- (A) SO_2 is obtained by roasting metal sulphides
 (B) SO_2 is acidic in nature
 (C) SO_2 is used as a disinfectant
 (D) SO_2 is an anhydride of H_2SO_4
- 69.** Which of the following is an anhydride of H_2SO_4 ?
- (A) H_2S (B) H_2S_2
 (C) SO_2 (D) SO_3
- 70.** Which of the following is an anhydride of H_2SO_3 ?
- (A) H_2S (B) H_2S_2
 (C) SO_2 (D) SO_3

METALS, NON-METALS						ANSWER KEY				EXERCISE					
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	A	D	B	B	D	A	B	C	A	C	D	C	B	D
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	D	D	C	C	B	D	B	C	D	B	D	B	C	C	D
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	B	A	C	C	D	D	A	D	A	D	D	B	C	C	D
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	B	C	B	C	B	C	B	C	D	D	B	D	D	D	B
Que.	61	62	63	64	65	66	67	68	69	70					
Ans.	A	A	C	D	C	C	C	D	D	C					



CARBON & ITS COMPOUNDS

INTRODUCTION

The compounds obtained from 'Carbon' are widely used as clothes, medicines, books, food, fertilizer, fuel etc. all living structures are carbon based.

The amount of carbon present in the earth's crust and in the atmosphere is quite merge. The earth's crust has only 0.02% carbon in the form of mineral (like carbonates, hydrogen-carbonates, coal and petroleum) and the atmosphere has 0.03% of carbon dioxide. In spite of this small amount of carbon available in nature, the importance of carbon seems to be immense.

Carbon forms a large number of compounds with hydrogen which are known as *hydrocarbons*. In addition to hydrogen, carbon compound may also contain some other element such as oxygen, halogen, nitrogen, phosphorus, sulphur etc.

The number of compounds of carbon is more than three million which is much larger than the compounds formed by all other element put together.

BONDING IN CARBON COMPOUNDS

Carbon forms **covalent bonds** in its compounds with other atoms. In each compound the valency of carbon is four. That is, carbon has **tetravalent** character. But what is covalent bond and what is meaning of tetravalent ?

COVALENT BOND:

A chemical bond formed between two atoms of the same element or two atoms of different elements by *sharing of electron* is called a **covalent bond**.

Necessary conditions of the formation of covalent bond :

- The combining atoms should have **nonmetallic** character.
- The combining atoms should contain **4 to 7 electrons** in their respective valence shell.
- In **hydrogen** there is only **1 valence electron**, but it also forms **covalent bond**.
- The combining atoms need **1, 2, 3 or 4 electrons** to complete their **octet (hydrogen completes its duplet)**
- The combining atoms should contribute equal number of electrons to form pair of electrons to be **shared**.
- After sharing the pair of electrons each combining atoms should attain stable electronic configuration like its nearest noble gas.

CLASSIFICATION OF COVALENT BOND :

On the basis of the number of electrons shared by two combining atoms, the covalent bond are of three types.

- **Single Covalent Bond** : A single covalent bond is formed by the sharing of one pair of electrons between the two atoms. It is represented by one short line (---) between the two atoms.
Example : H-H, Cl-Cl, H-Cl, CH₃-CH₃.
- **Double Covalent Bond** : A double covalent bond is formed by the sharing of two pairs of electron between the two combining atoms. It is represented by putting (=) two short lines between the two bonded atoms.
Examples : O = O (O₂), CO₂ (O = C = O), H₂C = CH₂
- **Triple covalent bond** : A triple bond is formed by the sharing of three pair of electrons between the two combining atoms. It is represented by putting three short line (≡) between two bonded atoms.
Example : N₂ (N≡N), CH≡CH.

FORMATION OF SINGLE COVALENT COMPOUNDS :

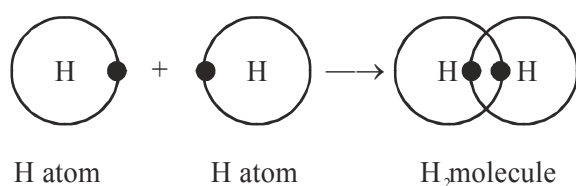
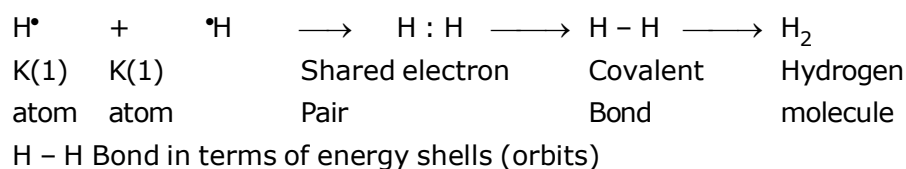
- **Formation of hydrogen molecule (H₂) :**

A molecule of hydrogen is composed of two H-atoms. The electronic configuration of H-atom is.



Shell - K }
Electron-1 } incomplete duplet (unstable)
Electronic configuration of He atom

Shell - K }
Electrons-2 } complete duplet (stable)



- **Formation of chlorine molecule (Cl₂).** The atomic number of chlorine is 17, thus there are 17 electrons in an atom of chlorine.

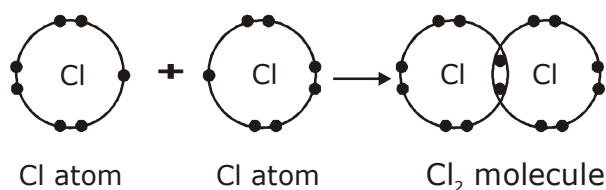
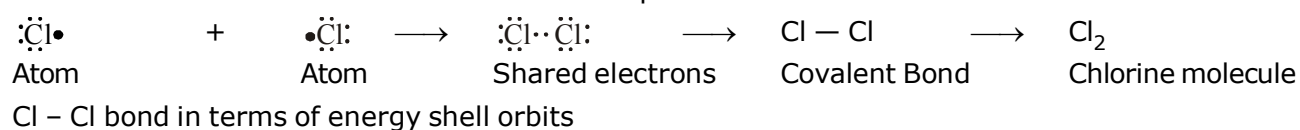
Electronic configuration of Cl atom -

Shells K L M }
Electrons 2 8 7 } Incomplete octet

Electronic configuration of Ar atom -

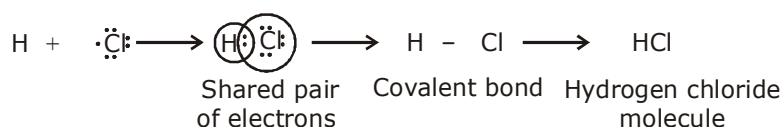
Shells K L M }
Electrons 2 8 8 } Complete octet

Chlorine atom needs one electron more to complete its octet -



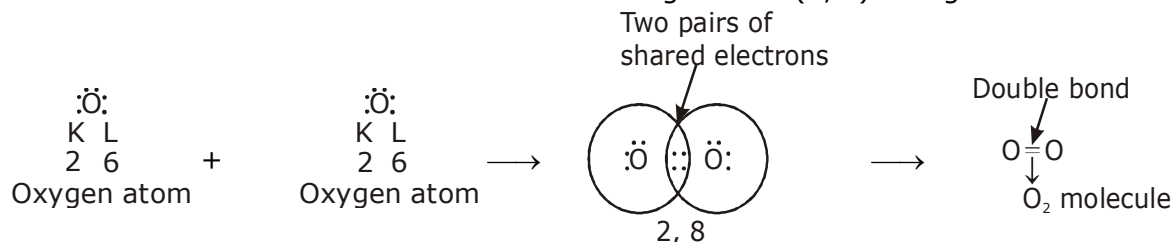
Formation of hydrochloric acid (HCl) :

- H atom has one valence electron. It needs 1 electron more to complete its duplet and chlorine atom has 7 valence electrons. It need 1 electron more to complete its octet and acquire stable electronic configuration (2, 8, 8) like noble gas argon.



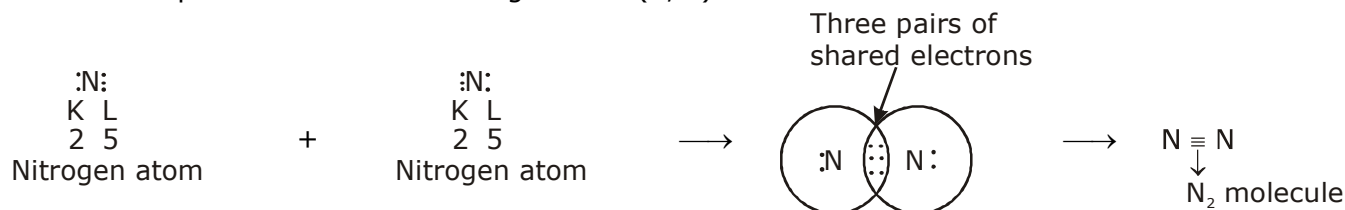
● **Formation of oxygen (O₂) :**

The atomic number of O atom is 8. There are 6 electron in the valence shell of oxygen atom it needs 2 more electrons to attain the nearest stable inert gas Neon (2, 8) configuration :



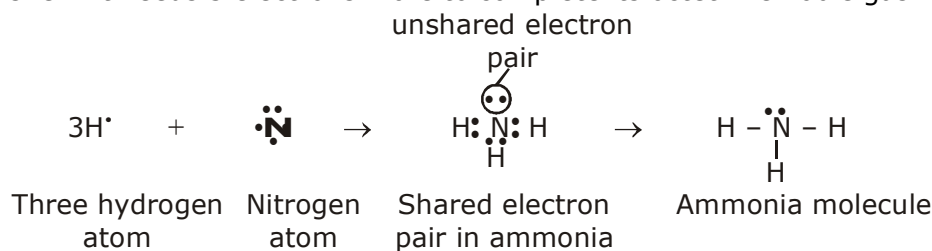
● **Formation of nitrogen molecule (N₂) :**

The atomic number of nitrogen is 7 and its electronic configuration is K(2), L(5). It needs 3 electrons more to complete its octet like noble gas neon (2, 8).



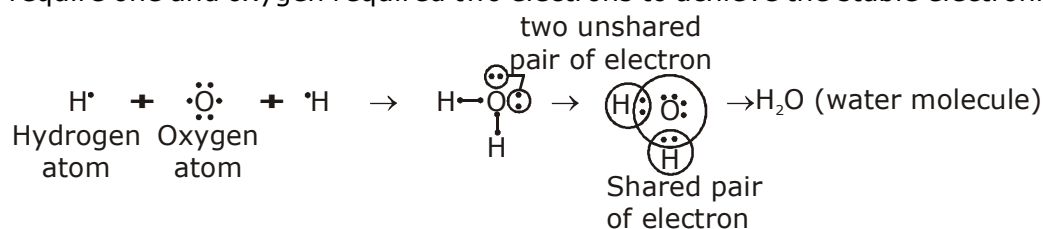
● **Formation of ammonia molecule (NH₃) :**

The atomic number of N is 7. It's electronic configuration is 2, 5 there are 5 electrons in its valence shell. It needs 3 electrons more to complete its octet like noble gas neon (2, 8).



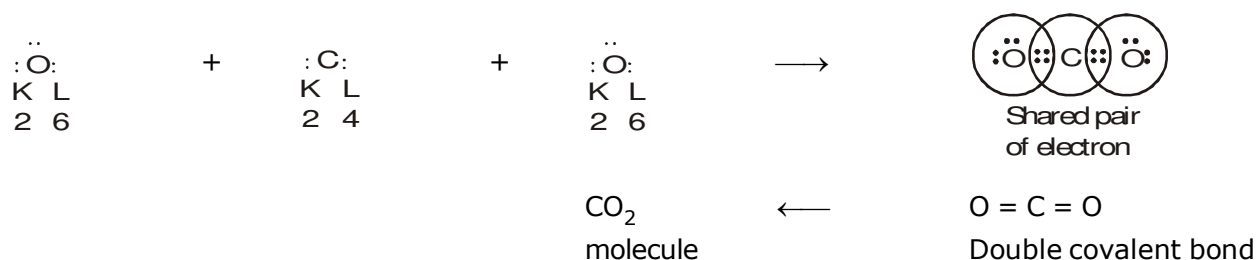
● **Formation of H₂O molecule :**

The electronic configuration of hydrogen is K (1) and that of oxygen is K(2) L(6) thus each hydrogen require one and oxygen required two electrons to achieve the stable electronic configuration.



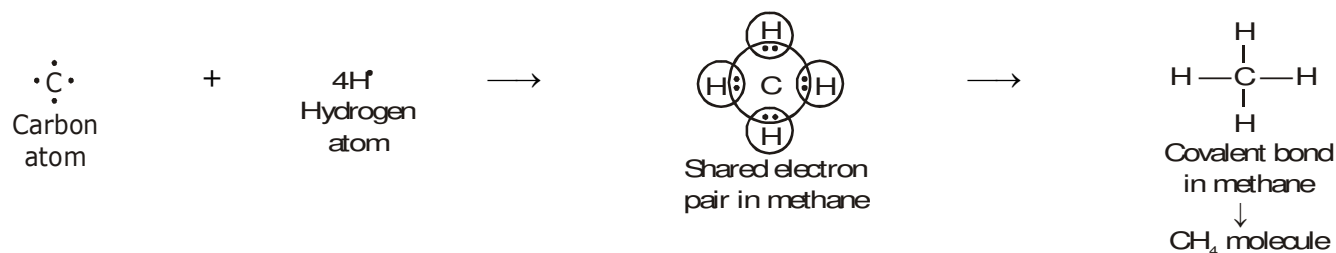
● **Formation of CO₂ molecule :**

The atomic number of C is 6 and the electronic configuration of C is K(2), L(4) and that of oxygen is K(2), L(6) thus each carbon require 4 and oxygen require two electrons to achieve the stable electronic configuration.



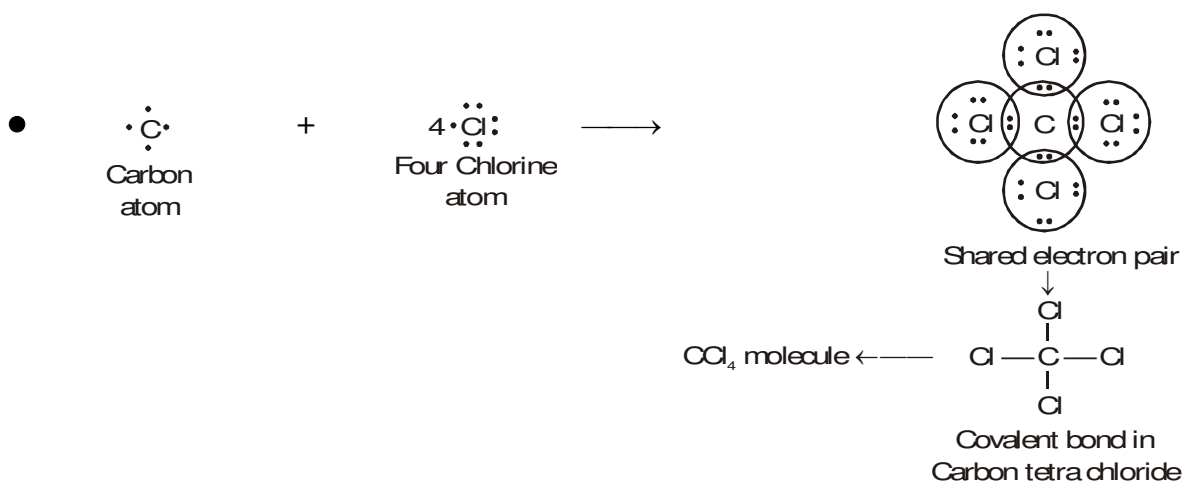
● **Formation of CH₄ molecule :**

Methane is a covalent compound containing 4 covalent bond. It contains one carbon atom and four hydrogen atom covalently bonded to central carbon atom.



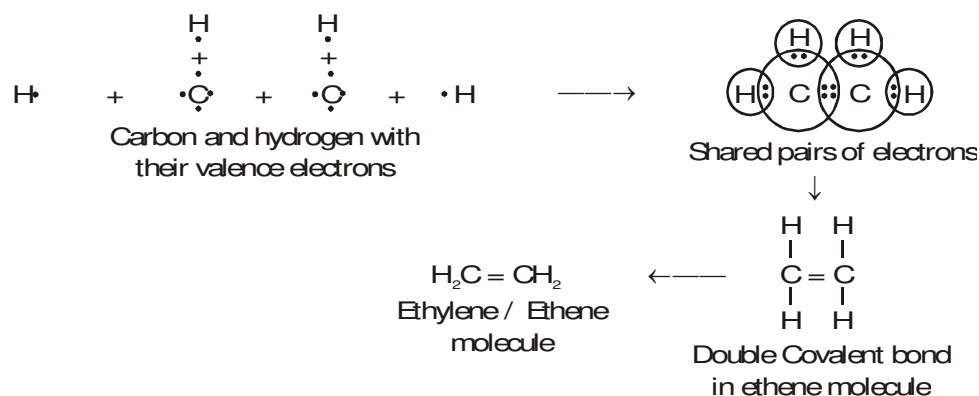
● **Formation of carbon tetrachloride molecule (CCl₄) :**

The electronic configuration of carbon and chlorine atoms are (2, 4) and (2, 8, 7) respectively. Carbon atom needs four electrons and chlorine atom needs one electron to attain the stable electronic configuration.

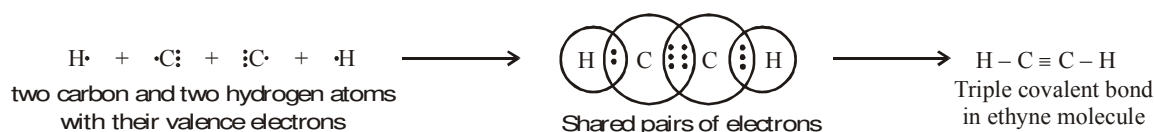


● **Formation of ethylene or ethene molecule (C₂H₄) :**

The electronic configuration of carbon atom is 2, 4. There are 4 valence electrons in one C atom. Each H atom contains 1 valence electron. Thus, there are 12 valence electrons present in ethene molecule.

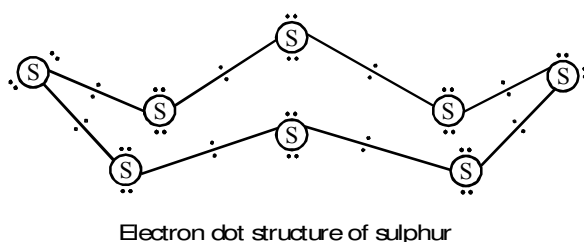


● **Formation of Acetylene or ethyne molecule (C_2H_2) :**



- Q. What would be the electron dot structure of carbon dioxide which has formula CO_2 ? [NCERT]
 Q. What would be the electron dot structure of a molecule of sulphur which is made up of eight atoms of sulphur?

Ans. The eight atoms of sulphur are joined together in the form of a puckered ring. [NCERT]

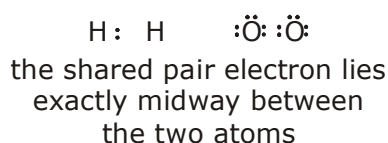


- Q. Explain the nature of the covalent bond using the bond formation in CH_3Cl . [NCERT]
 Q. Draw the electron dot structure for [NCERT]
 (a) Ethanoic acid (b) H_2S (c) Propanone (d) F_2

NON POLAR AND POLAR COVALENT COMPOUNDS:

Non polar covalent bond :

A covalent bond formed between **two atoms** of the same element or *same electronegativity* is called a **non-polar covalent bond**. Example : H_2 , N_2 , O_2 , Cl_2 etc.

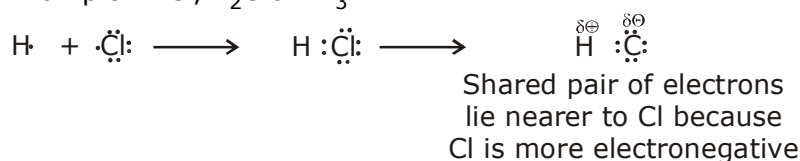


Polar covalent bond :

The covalent bond between the *atoms of two elements* having **different electronegativities** is called a **polar covalent bond**. Molecule in which the atom are bonded by a polar covalent bond are called **polar molecules**.

Note : In a polar covalent bond, the shared pair of electrons lies more toward the atom which is more electronegative.

Example : HCl , H_2O & NH_3



Note : δ means partial

Note: There are some exception in which central atom has less than eight electrons



CHARACTERISTICS OF COVALENT BOND AND COVALENT COMPOUNDS :**Characteristics of covalent bond :**

- Covalent bond are formed by mutual **sharing** of electrons
- Note :** Shared pair of electrons is also called **bonding pair of electrons**.
- Covalent bond is directional in nature because shared pair of electrons remain localized in a definite space between the two atoms.

Characteristics of covalent compounds :

Physical State : The covalent compounds are generally **gases or liquids**, but compounds with high molecular masses are **solids**.

Example : **Solid :** Urea, Glucose, Naphthalene.

Liquids : Water, ethanol, benzene.

Gases : Methane, chlorine, hydrogen, oxygen

- **Melting and boiling points :** Covalent compounds have **low melting** and **low boiling points** because **intermolecular forces** (cohesive forces) in covalent compounds **are weaker** than those in ionic compounds.

Note : Some exception like diamond and graphite which are covalent solids have very high M.P. & B.P.

- **Solubility :**

Covalent compounds generally dissolve readily in organic solvents but they are **less soluble in water**.

For example : Napthalene which is an organic compound dissolves readily in organic solvents like ether but is insoluble in water. However some covalent compounds like urea, glucose, sugar etc. are soluble in water. Some polar covalent compounds like ammonia and hydrochloric acid are soluble in water.

- **Conductivity :**

Covalent compounds **do not conduct electricity** because they contain neither the ions nor free electrons necessary for conduction, So they do not conduct electricity

For example : Covalent compounds like glucose, alcohol, carbon tetrachloride do not conduct electricity.

Differences between ionic and covalent compounds :

S.N.	Electrovalent (Ionic) Compounds	Covalent Compounds
1	Formed by transfer of electrons, (only single bond network exist)	Formed by sharing of electrons, (single, double & triple bond are formed).
2	Usually crystalline solid	Usually gases or liquid only a few of them are solid
3	Generally have high melting and boiling points	Generally have low M.P. and B.P.
4	Soluble in water but insoluble in organic solvents	Soluble in organic solvent but insoluble or soluble in water
5	Conduct electricity in solution or molten state	Usually non conductor of electricity
6	Highly polar and ionise in water eg. $\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$	Usually Non-polar and do not ionise in water but few compounds are polar in nature and ionise in water eg. $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$

ORGANIC COMPOUNDS

The chemical compounds which are present in living organisms (plant and animal) are called **organic compounds**. The belief that formation of organic compounds was possible only in plants and animals led the scientists of early days to propose that **Vital Force** was necessary for the formation of such compounds. But the experimental work of **Friedrich Wohler** (German chemist) denied the idea of vital force when he prepared urea in his laboratory. (urea is an organic compound and waste product of urine).



Q. Name the organic compound which was prepared by Wohler in his laboratory.

[NCERT]

Allotropy / allotropes of carbon :

The phenomenon of existence of allotropic forms of an element is called **allotropy**. Allotrops are the different forms of the same element having **different physical properties** but almost **similar chemical properties**. There are three allotrops of carbon these are diamond, graphite and fullerene.

DIAMOND : Diamond is a **crystalline allotrope** of carbon. Its atomic symbol & empirical formula is 'C'.



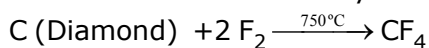
Structure of Diamond

Structure : In diamond, each carbon atom is covalently bonded to four other carbon atoms in a tetrahedral arrangement. This tetrahedral arrangement of carbon atoms gives a rigid, three dimensional structure to diamond. It is due to this rigid structure that diamond

- Is very hard crystalline structure.
- Has high melting point.
- Is non conductor of heat and electricity.

Properties : Pure diamond is a transparent and colourless solid.

- Polished diamond sparkles brightly because it reflects most of the light (refractive index of diamond is 2.45)
- Diamond are not attacked by acids, alkalis and solvents like water, ether, benzene or carbon tetrachloride but diamond is attacked by fluorine at 750°C.



Carbon Fluorine Carbontetrafluoride

- The density of diamond is 3.51 g per cm³ at 20°C.

Uses :

- A saw fitted with diamond is used for sawing marbles.
- A chip diamond is used for glass cutting.
- Black diamonds are used in making drill.
- Diamonds are used for making dice for drawing very thin wires of harder metals.
- Diamonds are also used for making high precision tools for use in surgery such as, for the removal of cataract.
- Diamond are used for making precision thermometers and protective windows for space crafts.

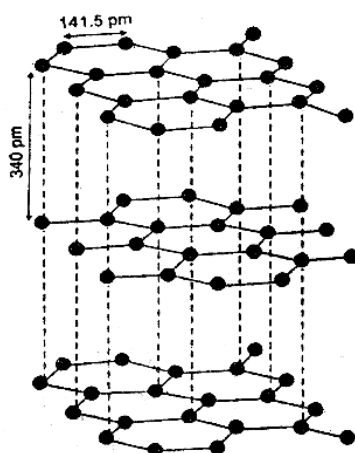
GRAPHITE :

Graphite is also known as **black lead** it marks paper black. The name graphite has been taken from the Greek word "**graphein**" (which means to write) in reference to its uses as 'lead' in lead pencils.

Structure :

Graphite is an opaque and dark grey solid. In a crystal of graphite the carbon atoms are arranged in hexagonal patterns in parallel planes. In a layer of graphite each carbon atom is strongly bonded to three carbon atoms by covalent bonds. Thus, one valence electron of each carbon atom is free in every layer of graphite crystal. The free electron makes graphite a good conductor of electricity. Each layer is bonded to the adjacent layers by weak forces. As a result, each layer can easily slide over the other.




Properties :

- Graphite is greyish -black, opaque material having metallic (shiny) **lustre**.
- It is soft and has a **soapy** (slippery) touch.
- Graphite is **lighter** than diamond. The **density of graphite** is 2.26 g per cm^3 at 20°C .
- Graphite is a **good conductor** of heat and electricity.
- Graphite has a very **high melting point**.
- Graphite is **insoluble** in all common solvent.

Uses :

- For making electrodes in dry cells and electric arc furnaces.
- Graphite is a **good dry lubricant** for those parts of machines where grease and oil cannot be used.
- For making crucibles for melting metals.
- For manufacturing lead pencils.
- Graphite is used as neutron moderator in nuclear reactors.
- For the manufacture of gramophone records and in electrotyping.
- For the manufacture of artificial diamond.

Fullerene :

- Fullerene was discovered in 1985 by Robert F. Curl Jr, Harold Kroto and Richard E. Smally.
- This molecule containing sixty atoms of carbon has been named Buckminster fullerene. Fullerenes has been named after American architect and engineer **R. Buckminster-fuller** whose geodesic domes follow similar building principles.

Types of fullerene :

C_{60} , C_{70} , C_{74} and C_{78} are the members of the fullerene family. But C_{60} is the most stable and most studied form of fullerenes.

Structure of fullerene :

- Buckminster fullerene molecule (C_{60}) is nearly spherical.
- It consists of 12 pentagonal faces and 20 hexagonal faces giving it 60 corners. Thus, Buckminster fullerene has a hollow, cage-like structure.
- In figure, ball like molecules containing C atoms.

Preparation :

- By electrically heating a graphite rod in atmosphere of helium.
- By vaporising graphite by using laser.

Properties :

- Fullerene is soluble in benzene and forms deep violet colour solution.
- Crystalline fullerene has semiconductor properties.



- Compounds of fullerene with alkali metals are called fullerides and they are superconductors.

Uses :

- As a superconductor.
- As a semiconductor.
- As a lubricants and catalyst.
- As fibres to reinforce plastics.

VERSATILE NATURE OF CARBON

About three million (or thirty lakh) compounds of carbon are known. The existence of such a large number of organic compounds is due to the following characteristic features of carbon.

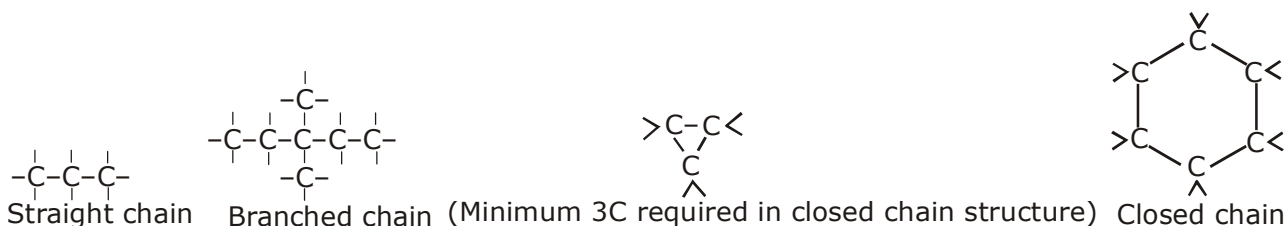
(1) CATENATION : Tendency to form Carbon-Carbon bond :

"The property of forming bonds with atoms of the same element is called **catenation**".

Carbon has the maximum tendency for catenation in the periodic table. This is because of strong carbon carbon bonds as compared to other atoms.

Note: Silicon also show catenation.

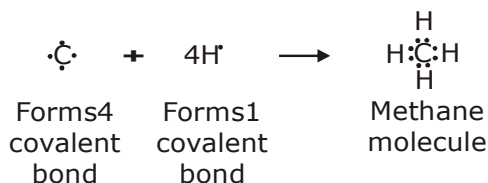
- When two or more carbon atoms combine with one another, they form different types of chain such as
 - Straight chains
 - Branched chains
 - Closed chain or ring chains



- The property of catenation is due to
 - small size of C atom
 - Great strength of carbon - carbon bond.

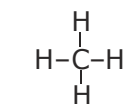
(2) Tetravalency of Carbon :

- The atomic number of carbon is **6**.
- The electronic configuration of carbon atom is **1s², 2s², 2p²**.
- It has four electrons in the outermost shell, therefore its valency is four. Thus carbon forms four covalent bonds in its compounds.

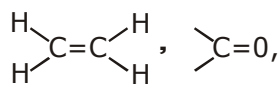
**(3) Tendency to form multiple bonds :**

Due to small size, carbon can easily form double or triple bonds (**called multiple bonds**) with itself and with the atoms of other elements as nitrogen, oxygen, sulphur etc.

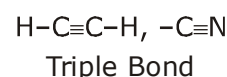




Single Bond



Double Bond



Triple Bond

HOMOLOGOUS SERIES

"A series of organic compounds having similar structures and similar chemical properties in which the successive members differ in their molecular formula by $-\text{CH}_2$ group".

The different members of the series are called **homologous**.

Characteristics of Homologous Series :

- All the member of a homologous series can be described by a common general formula.
- **Example :** All alkane can be described by the general formula $\text{C}_n\text{H}_{2n+2}$.
- Each member of a homologous series differ from its higher and lower neighbouring members by a common difference of $-\text{CH}_2$ group.
- Molecular masses of the two adjacent homologues differ by 14 mass units, because molecular mass of $-\text{CH}_2$ group is $12 + 2 = 14$.
- All the members of a homologous series show similar chemical properties.
- All the members of the series can be prepared by similar methods known as the general method of preparation.

Table : Some members of alkane, alkene and alkyne homologous series.

Alkane		Alkene		Alkyne	
$\text{C}_n\text{H}_{2n+2}$		C_nH_{2n}		$\text{C}_n\text{H}_{2n-2}$	
Homologous series		Homologous series		Homologous series	
Name	Formula	Name	Formula	Name	Formula
Methane	CH_4	–	–	–	–
Ethane	C_2H_6	Ethene	C_2H_4	Ethyne	C_2H_2
Propane	C_3H_8	Propene	C_3H_6	Propyne	C_3H_4
Butane	C_4H_{10}	Butene	C_4H_8	Butyne	C_4H_6
Pentane	C_5H_{12}	Pentene	C_5H_{10}	Pentyne	C_5H_8
Hexane	C_6H_{14}	Hexene	C_6H_{12}	Hexyne	C_6H_{10}

Activity : Calculate the difference in the formulae and molecular masses for (a) CH_3OH and $\text{C}_2\text{H}_5\text{OH}$ (b) $\text{C}_2\text{H}_5\text{OH}$ and $\text{C}_3\text{H}_7\text{OH}$ and (c) $\text{C}_3\text{H}_7\text{OH}$ and $\text{C}_4\text{H}_9\text{OH}$

- Q. It there any similarity in these three ? [NCERT]
- Q. Arrange these alcohols in the order of increasing carbon atoms to get a family. Can we call this family a homologous series ? [NCERT]
- Q. What is homologous series? Explain with an example. [NCERT]

Solution :



Formula		Molecular Mass (Calculated)	Formula	Difference In Molecular mass
a.	CH ₃ OH	12+3+16+1=32	-CH ₂	14
	C ₂ H ₅ OH	24+5+16+1=46		
b.	C ₂ H ₅ OH	24+5+16+1=46	-CH ₂	14
	C ₃ H ₇ OH	36+7+16+1=60		
c.	C ₃ H ₇ OH	36+7+16+1=60	-CH ₂	14
	C ₄ H ₉ OH	49+9+16+1=74		

Conclusion :

- (i) Yes, all these compounds are the members of a homologous series for alcohols.
- (ii) CH₃OH, C₂H₅OH, C₃H₇OH and C₄H₉OH -increasing carbon atoms. These four compounds form a homologous series.

HOMOLOGOUS SERIES CONTAINING FUNCTIONAL GROUPS.

- **Aldehydes :**
HCHO, CH₃CHO, CH₃CH₂CHO, CH₃CH₂CH₂CHO
- **Carboxylic acids :** HCOOH, CH₃COOH, CH₃CH₂COOH, CH₃CH₂CH₂COOH
- **Amines :** CH₃NH₂, CH₃CH₂NH₂, CH₃CH₂CH₂NH₂.
- **Ketones :** CH₃COCH₃, CH₃COCH₂CH₃, CH₃COCH₂CH₂CH₃
- **Haloalkanes :** CH₃X, CH₃CH₂X, CH₃CH₂CH₂X, CH₃CH₂CH₂-CH₂X

How do physical properties change in a homologous series of hydrocarbons.

The physical properties of the various members of a homologous series change regularly with an increase in the molecular mass.

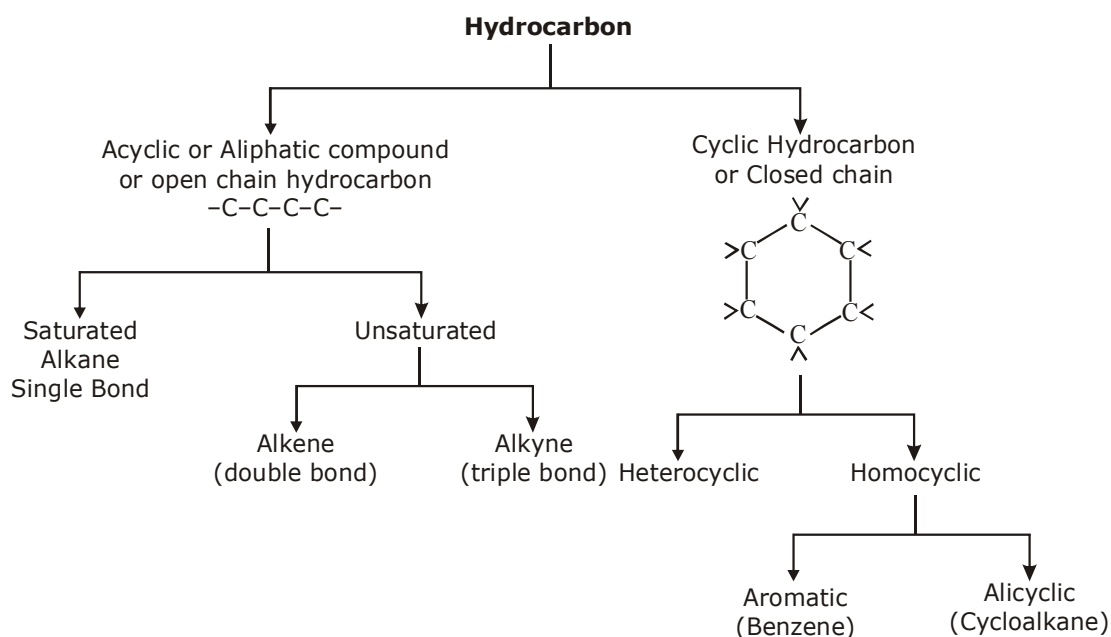
- (i) **Melting and boiling points :** Melting point and boiling point of hydrocarbon in a homologous series increases with an increase in molecular mass.
- (ii) **Physical State :**
- Hydrocarbons containing lesser number of carbon atoms are **gases**.
 - Hydrocarbons containing large number of carbon atoms are **solids**.
 - Hydrocarbon containing intermediate number of carbon atoms are **liquid**.

Example : Hydrocarbon containing 1-4 carbon atoms are gases, these containing 5-13 carbon atoms are liquid and those containing more than 14 carbon atoms are solids.

HYDROCARBON

Compounds formed from combination of carbon and hydrogen are known as hydrocarbon. Hydrocarbon on the basis of chain are mainly classified into two parts.





Saturated and unsaturated hydrocarbon :

(1) Saturated Hydrocarbon :

- The hydrocarbons which contain only single carbon-carbon covalent bonds are called **saturated hydrocarbons**.
- They are also called **alkanes**.
- General formula for alkanes is C_nH_{2n+2} where 'n' is the number of carbon atoms.

General formula of saturated hydrocarbon (C_nH_{2n+2})

No. of 'C' atoms	Name	Formula	Structure
1	Methane	CH_4	<pre> H H - C - H H </pre>
2	Ethane	C_2H_6	<pre> H H H - C - C - H H H </pre>
3	Propane	C_3H_8	<pre> H H H H - C - C - C - H H H H </pre>
4	Butane	C_4H_{10}	<pre> H H H H H - C - C - C - C - H H H H H </pre>
5	Pentane	C_5H_{12}	<pre> H H H H H H - C - C - C - C - C - H H H H H H </pre>
6	Hexane	C_6H_{14}	<pre> H H H H H H H - C - C - C - C - C - C - H H H H H H H </pre>

(2) Unsaturated hydrocarbons :

The hydrocarbon in which two carbon atoms are bonded to each other by a double (=) or a triple (\equiv) bond is called an unsaturated hydrocarbon.

- Unsaturated hydrocarbons are of two types viz. alkenes and alkynes.

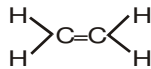
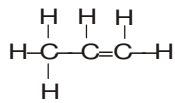
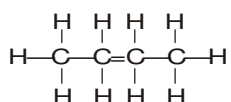
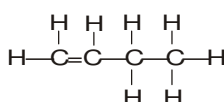


CARBON & ITS COMPOUNDS

(I) Alkenes : $(-\text{C}=\text{C}-)$

- The hydrocarbon in which the two carbon atoms are bonded by a double bond are called **alkenes**.
- Their general formula is C_nH_{2n} where "n" is the number of carbon atoms.

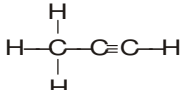
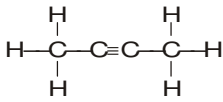
General formula of alkenes : C_nH_{2n}

No. of C atoms	Name	Formula	Structure
2	Ethene or	C_2H_4	
3	Ethylene	$\text{CH}_2=\text{CH}_2$	
4.	Propene or Propylene	C_3H_6 $\text{CH}_3-\text{CH}=\text{CH}_2$	
	Butene or	C_4H_8	
	Butylene	$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$	
		or	or
		$\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_3$	

(II) Alkyne ($-\text{C}\equiv\text{C}-$)

- The hydrocarbon in which two carbon atoms are bonded by a triple bond are called **alkyne**.
- Their general formula is $\text{C}_n\text{H}_{2n-2}$ where 'n' is the number of carbon atoms.

General formula of alkynes : $\text{C}_n\text{H}_{2n-2}$

No. of 'C' atoms	Name	Formula	Structure
2	Ethyne or Acetylene	C_2H_2 or $\text{HC}\equiv\text{CH}$	$\text{H}-\text{C}\equiv\text{C}-\text{H}$
3	Propyne or	C_3H_4 or	
	Methyl acetylene	$\text{H}_3\text{C}-\text{C}\equiv\text{C}-\text{H}$	
4	Butylene or	C_4H_6 or	
	Dimethyl acetylene	$\text{H}_3\text{C}-\text{C}\equiv\text{C}-\text{CH}_3$	

Q. Give a test that can be used to differentiate chemically between butter and cooking oil. **[NCERT]**

CHAINS, BRANCHES AND RINGS :

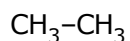
The hydrocarbons may also have branched, closed chains or ring or cyclic structures.

Branched structure :

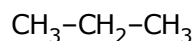
The alkanes containing three or less carbon atoms do not form branches.



Methane



Ethane



Propane



CARBON & ITS COMPOUNDS

- The alkane containing four carbon atoms (C_4H_{10}) has two types of arrangement of carbon atoms.

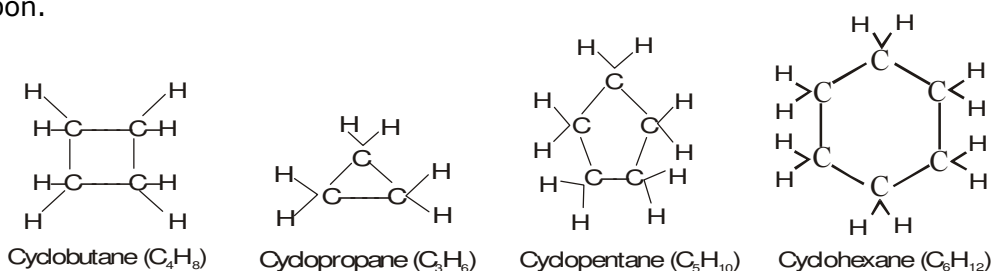


- Closed chains or cyclic hydrocarbon :**

These hydrocarbons contain closed chain or rings of atoms in their molecules. These are of two types:

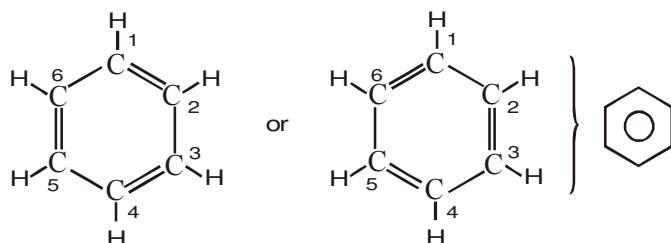
(A) Alicyclic hydrocarbon :

- These hydrocarbons contain a ring chain of three or more carbon atoms.
- These cyclic compounds are named by prefixing cyclo before the name of corresponding straight chain hydrocarbon.



(B) Aromatic hydrocarbon :

- These have at least one benzene ring in their molecules.
- It is a special type of ring of six carbon atoms with three double bonds in alternate positions.



Will you be my friend ? (Functional group) :

- Carbon forms many compounds with hydrogen. But carbon also forms bonds with other atoms such as halogen, oxygen, nitrogen and sulphur. Therefore, carbon is said to be very friendly element. These compounds are obtained by replacing one or more hydrogen atoms by other atoms such that the valency of carbon remains satisfied. The atom replacing the hydrogen atom is called **heteroatom** or **Functional group**.
- Different organic compounds having same functional group have almost same properties these are called **families**.

Example :



- Properties of CH_3-OH and CH_3-CH_2OH are similar and it is due to the presence of $-OH$ (hydroxyl) group.
- This group is known as **alcoholic group**.
- Family of compounds having $-OH$ group is called **alcohols**.



SOME FUNCTIONAL GROUPS IN CARBON COMPOUNDS

Hetero atom	Functional Group	Formula of Functional Group
Halogen atom (F, Cl, Br, I)	Halo (Fluoro, Chloro, Bromo, Iodo)	-X (-F, -Cl, -Br, -I)
Oxygen	1. Alcohol	-OH
	2. Aldehydes	$\begin{array}{c} \text{H} \\ \diagup \\ \text{C} \\ \parallel \\ \text{O} \end{array}$ or -CHO
	3. Ketones	$\begin{array}{c} \diagup \\ \text{C} = \text{O} \\ \diagdown \end{array}$ or $\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$
	4. Carboxylic acid	$\begin{array}{c} \text{O} \\ \parallel \\ -\text{C}- \end{array} \text{OH}$ or -COOH
Nitrogen	1. Nitro	-NO ₂
	2. Amines	-NH ₂

Nomenclature of carbon compounds :

Carbon compounds can be called by their common names, but, then remembering millions of compounds by their individual names may be very difficult. Due to this reason, **the International Union of Pure and Applied chemistry (IUPAC)** has devised a very systematic method of naming these compounds.

Naming a carbon compound can be done by the following methods.

- The number of carbon atoms in the molecule of a hydrocarbon is indicated by the following stems.

No. of carbon atom	1	2	3	4	5	6	7	8	9	10	11	12	20
Stem	Meth	Eth	Prop	But	Pent	Hex	Hept	Oct	Non	Dec	Undec	Dodec	Eicos

Example : Saturated hydrocarbon.

Alkane → Meth + ane = Methane

Unsaturated hydrocarbon

Alkene → Eth + ene = Ethene

Alkyne → Eth + yne = Ethyne

- In case of functional group is present, it is indicated in the name of compound with either a prefix or a suffix.
- Identify the longest continuous chain of carbon atoms. This gives the name of parent hydrocarbon.
- In the case of any substituent appropriate prefix is added before the name of parent hydrocarbon.
- In the case of a functional group, the ending 'e' in the name of the parent hydrocarbon is replaced by the appropriate suffix.

⇒ Functional Group :

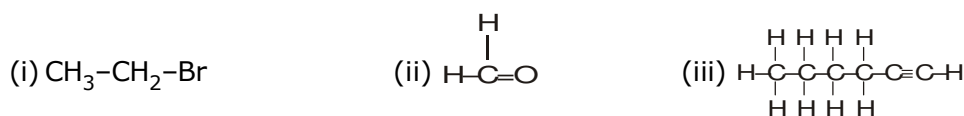
"Functional group may be define as an atom or a group of atoms which is responsible for most of the characteristic chemical properties of an organic compound".



The prefixes and suffixes of some substituents/functional group

Class	Functional Group	General Formula	Prefix	Suffix	IUPAC Name
Carboxylic acid	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \\ (\text{R} = \text{C}_n\text{H}_{2n+1}) \end{array}$	Carboxy	- oic acid	Alkanoic acid
Ester	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OR} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{O}-\text{R}' \end{array}$	Carbalkoxy or alkoxy carbonyl	alkyl (R') - oate	Alkyl alkanoate
Aldehyde	-CHO	R-CHO	Formyl or oxo	- al	Alkanal
Ketone	$\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{R} \end{array}$	oxo	- one	Alkanone
Alcohol	-OH	R-OH	Hydroxy	- ol	Alkanol
Alkenes	$\begin{array}{c} \diagup \quad \diagdown \\ \text{C} = \text{C} \\ \diagdown \quad \diagup \end{array}$	C_nH_{2n}	—	- ene	Alkene
Alkynes	$-\text{C} \equiv \text{C}-$	$\text{C}_n\text{H}_{2n-2}$	—	- yne	Alkyne
Halides	$\begin{array}{c} -\text{X} \\ (\text{X} = \text{F}, \text{Cl}, \text{Br}, \text{I}) \end{array}$	R-X	Halo	—	Haloalkane

- Q. How many structure isomers can you draw for pentane ?
- Q. What will be the formula and electron dot structure of cyclopentane ?
- Q. Draw the structure for the following compounds :
- (i) Ethanoic acid (ii) Bromopentane (iii) Butanone (iv) Hexanal
- Q. Draw the possible structural isomers for bromopentane.
- Q. How would you name the following compounds ?

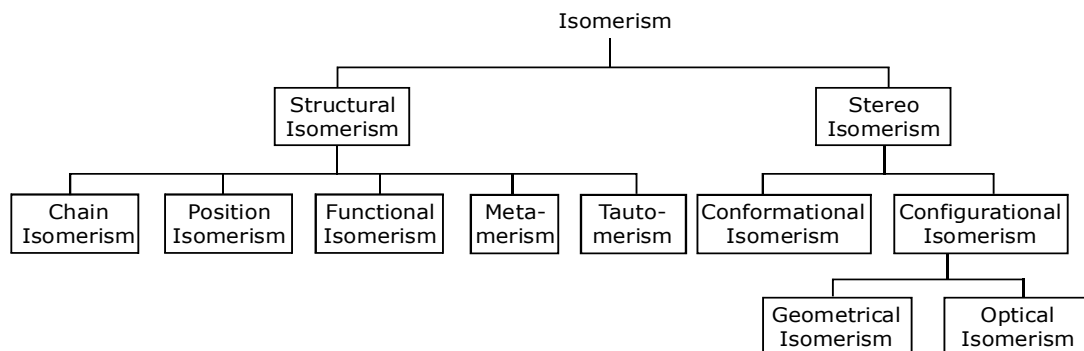

ISOMERISM

Definition: Compounds having same molecular formula show different physical and chemical properties are called isomers and the phenomenon is called isomerism.

The difference in properties of isomers is due to the difference in the relative arrangements of various atoms present in their molecules. Organic compound show following types of structural isomerism on the basis of their difference in structural arrangement of atoms.

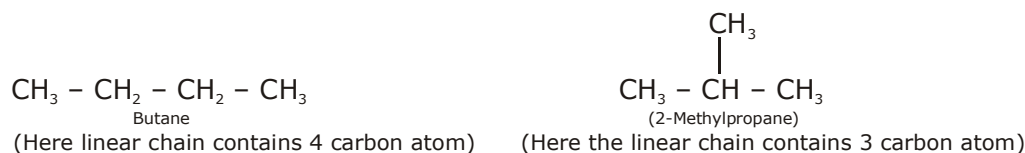


- ◆ **Type of Isomerism:** The following figure shows the pictorial representation of different types of isomerism



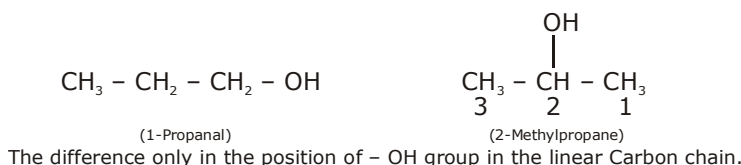
- ◆ **Chain isomerism:** Organic compounds having same molecular formula but difference in the nature of length carbon chain are called chain isomers.

For example, Let us consider the molecular formula of an alkane C_4H_{10} .

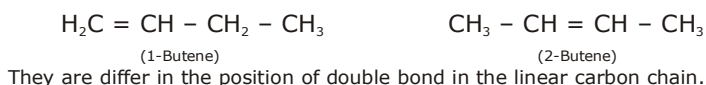


- ◆ **Position isomerism:** Compounds having same molecular formula but differ in the position of, functional group, double bond or triple bond in the carbon chain are called position isomers. This type of isomerism is shown by Alkene, Alkyne, Alcohol, Amine, Haloalkane etc.

Ex.1 Let us consider the molecular formula of an alcohol $(C_nH_{2n+2}O)C_3H_8O$



Ex.2 Let us consider the molecular formula of alkene $C_4H_8(C_nH_{2n})$



- ◆ **Functional isomerism:** Compounds having same molecular formula but differ in nature of functional group are called functional isomers.

Ex.1 Alcohol and ether have same molecular formula $(C_nH_{2n+2}O)$ but have different functional group hence show functional isomerism. C_2H_6O



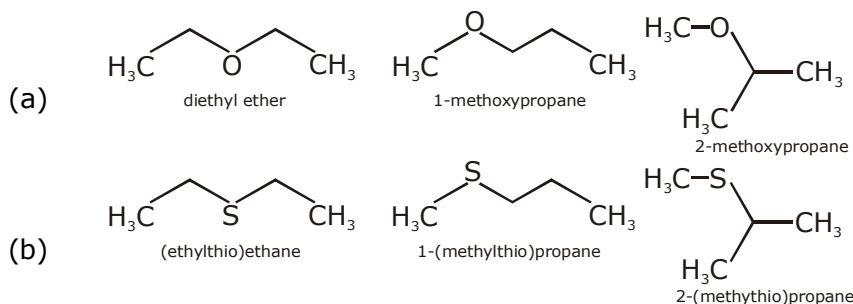
Ex.2 Aldehyde and Ketone having same molecular formula $(C_nH_{2n}O)C_3H_6O$



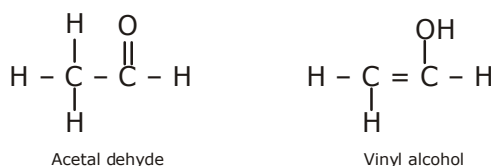
- ◆ **Metamerism:** The compounds having same molecular formula but different number of carbon atoms (or alkyl groups) on either side of functional group, are called metamers.



E.g. ethers, thioethers, secondary amines, ketones, esters etc.



- ◆ **Tautomerism:** This is a special type of functional isomerism in which the isomers differ in the arrangement of atoms but they exist in dynamic equilibrium with each other. For example, acetaldehyde and vinyl alcohol are tautomers.



◆ KNOWLEDGE ENHANCE:

Stereoisomerism is exhibited by compounds which have same structural formula and sequence of bonds but differ in the relative position of atoms or groups of atoms in space. It is majorly of two types

1. Geometrical Isomerism
2. Optical Isomerism

1. **Geometrical Isomerisms** also called cis trans isomerism is exhibited by alkenes because of the presence of double bond. This is due to the restricted rotation around carbon-carbon double bond. As a result, the position of the groups attached to these carbons is fixed in space. Here cis-isomer has identical groups on either side whereas trans-isomer has identical groups at opposite sides of $\text{C}=\text{C}$.



2. **Optical Isomerism** is shown by substances which can rotate the plane of polarised light. For example, this type of isomerism is shown by amino acid alanine.

Note: You will study about stereoisomerism in detail in higher classes.

⇒ CHEMICAL PROPERTIES OF CARBON COMPOUND :

All carbon compounds show some common characteristic properties. As most of the fuels we use are either carbon or its compounds. Some such properties are described here :

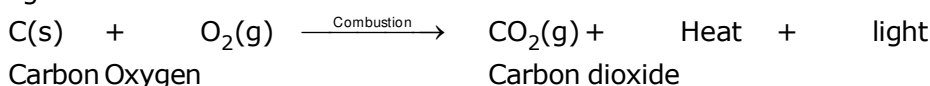
COMBUSTION :

Combustion is a chemical process in which heat and light (in the form of flame) are given out.

The process of combustion, is a rapid oxidation reaction of any substance in which heat and light are produced.

Combustion of some common substance :

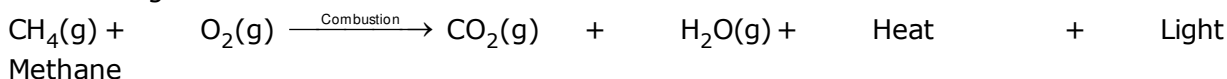
- **Combustion of Carbon :** Carbon (or charcoal) burns in air or oxygen to give CO_2 producing heat and light.



- Q. Why carbon and its compounds are used as fuels for most applications?

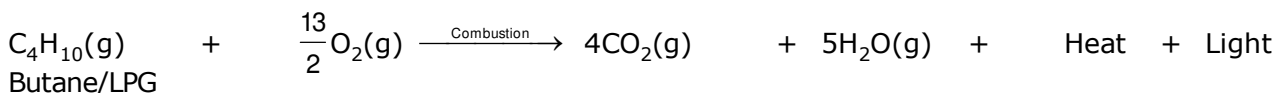


- **Combustion of Hydro Carbon :** Hydrocarbons burn to produce carbon dioxide (CO₂), water (H₂O) and heat and light.



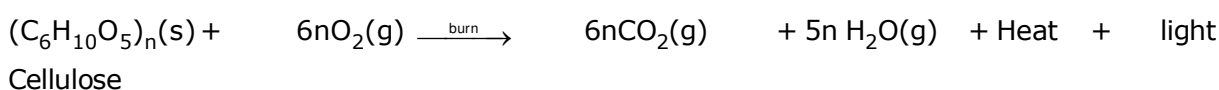
Note : Natural gas and biogas contain methane. So, burning of natural gas and biogas are also combustion reactions.

Burning of LPG (Butane) produces CO₂, H₂O heat and light.

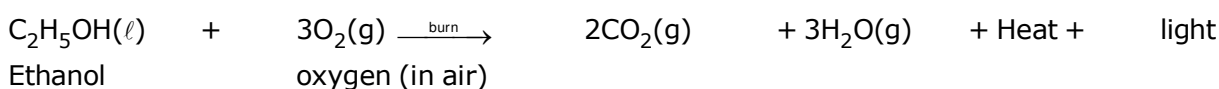


- **COMBUSTION OF CELLULOSE :**

Combustion of cellulose (like wood, cotton cloth and paper) gives CO₂, H₂O heat and light. Cellulose is a carbohydrate and can be described by the formula (C₆H₁₀O₅)_n.



- Combustion of alcohol :



Activity : To observe the combustion of given organic compounds.

Materials : Benzene, naphthalene, Camphor, alcohol (ethanol). Spirit, acetone.

Procedure :

1. Take each compound on iron spatula and burn them in Bunsen burner.
2. Record the type of flame produced.
3. Put a metal plate above the flame and observe whether or not there is black carbon deposition.

Observation :

Compound used	Flame Produced	Deposit
Benzene	Smoky flame	Carbon deposited
Naphthalene	Smoky flame	Carbon deposited
Camphor	Smoky flame	Carbon deposited
Alcohol	Non-Luminous flame	No Carbon deposited
Spirit	Non-Luminous flame	No Carbon deposited
Acetone	Non-Luminous flame	No Carbon deposited

Conclusion :

Benzene, naphthalene, camphor burn with smoky flame and carbon particles get deposited they undergo incomplete combustion due to excess of carbon content.

- Alcohol, spirit and acetone burn with non-Luminous flame and no carbon gets deposited. They undergo complete combustion, therefore produce more heat.

Activity : To study the different types of flames / presence of smoke.

Material required : Bunsen burner.

Procedure :

1. Light the *bunsen burner*.
2. Close the air hole and observe the colour of the flame.
3. Put a metal plate over it and observe the nature of deposit.
4. Open the air regulator to allow flow of air.
5. Observe the colour of flame.
6. Put a metal plate and observe the nature of deposit.



Observation :

Air Regulator	Colour of flame	Nature of deposit	Nature of flame	Temperature
Closed	Yellow sooty flame	Black carbon deposited	Reducing flame	low
Open	Bluish flame	No black carbon deposited	Oxidising flame	High

Conclusion : Keep the air regulator open to get oxidising, non-sooty flame which has high temperature and does not lead to black deposits.

COMBUSTION AND THE NATURE OF FLAME :

- Saturated hydrocarbon such as, methane, ethane, propane, butane and natural gas and LPG burn with a blue flame in the presence of sufficient / excess of air / oxygen.
- In the presence of limited amount of air / oxygen, saturated hydrocarbon, such as, methane, butane. etc give smoky flame.
- Unsaturated hydrocarbon such as ethene, ethyne etc. burn with a luminous / yellow smoky flame.
- The gas / kerosene stove used at home has inlets for air so that a sufficiently oxygen rich mixture is burnt to give a clean blue flame. If you carefully observe the bottoms of vessels getting blackened, it is clear indication that the air holes are blocked and the fuel is getting wasted.
- Fuels, such as coal and petroleum, have some amount of nitrogen and sulphur in them. Combustion of coal and petroleum results in formation of oxides of sulphur and nitrogen (such as sulphur dioxide, nitric oxide, nitrogen peroxide) which are major pollutants in the environment.

FORMATION OF COAL AND PETROLEUM :

Coal and petroleum have been formed from biomass which has been subjected to various biological and geological processes.

Coal is a naturally occurring black mineral and is a mixture of free carbon and compounds of carbon containing hydrogen, oxygen, nitrogen and sulphur. It is not only a good fuel but is also a source of many organic compounds. It is found in coal mines deep under the surface of earth.

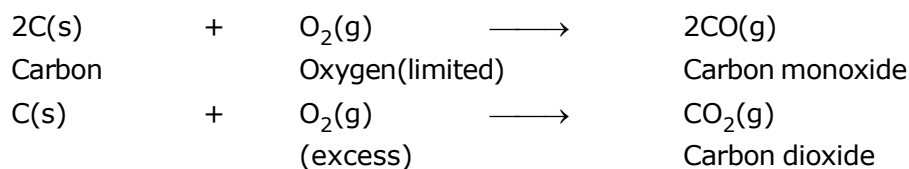
Coal is believed to be formed from fossils which got buried inside the earth during earthquakes and volcanoes which occurred about 300 million years ago. Due to huge pressure and temperature inside the earth and in the absence of air, the fossils fuels (vegetable matter or wood, etc.) were converted into coal. The slow chemical processes of the conversion of wood into coal is called **carbonization**. Since coal is formed by slow carbonization of plants and fossils, it produces many important carbonisation products like peat, lignite, bituminous and anthracite etc. and is itself known as **fossil fuel**. Coal is also a **non-renewable source** of energy.

Petroleum is a complex mixture containing various hydrocarbons (compounds of carbon and hydrogen) in addition to small amounts of other organic compounds containing oxygen, nitrogen, and sulphur. It is a dark coloured, viscous and foul smelling crude oil. The name petroleum is derived from latin words : "**petra**" meaning rock and "**oleum**" meaning oil. Since petroleum is found trapped between various rocks, it is also known as **rock oil**.

OXIDATION

Carbon and its compounds can be easily oxidised on combustion (or burning). During combustion / burning, the compounds gets oxidised completely to different products, depending upon the nature of the oxidising agents.

- Carbon gives carbon monoxide or carbondioxide depending upon the oxygen available.

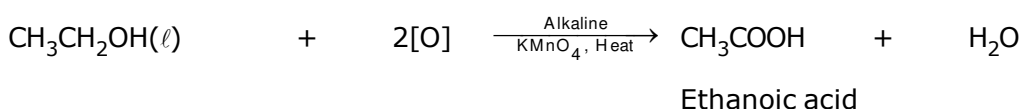
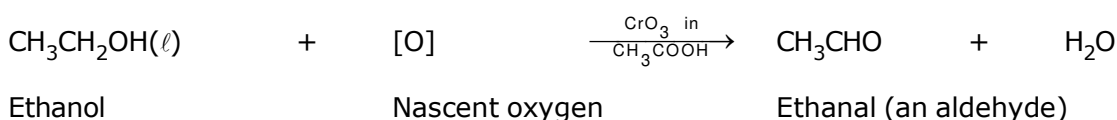


CARBON & ITS COMPOUNDS

- Hydrocarbon when oxidised give different product as follows :
$$\begin{array}{ccccccc} \text{CH}_4(\text{g}) & + & 2\text{O}_2(\text{g}) & \xrightarrow{\text{Complete oxidation}} & \text{CO}_2(\text{g}) & + & 2\text{H}_2\text{O}(\text{g}) \\ \text{Methane} & & \text{Oxygen(excess)} & & & & \\ 2\text{CH}_4(\text{g}) & + & 3\text{O}_2(\text{g}) & \xrightarrow{\text{Incomplete oxidation}} & 2\text{CO}(\text{g}) & + & 4\text{H}_2\text{O}(\text{g}) \\ \text{Methane} & & \text{Oxygen(Limited)} & & & & \end{array}$$
- Alcohols also give different products on oxidation depending upon the reaction conditions.

Example :

Alcohols on oxidation with certain oxidising agents such as chromic anhydride in acetic acid, yield corresponding aldehydes, where as on oxidation with alkaline potassium permanganate (or acidified potassium dichromate) corresponding carboxylic acid is formed, as given below :



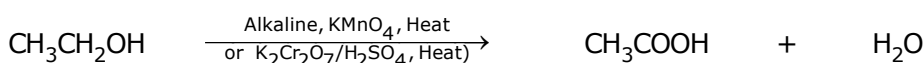
Activity : To study the reaction of ethanol with alkaline potassium permanganate :

Material required : Ethanol, alkaline KMnO_4 , test tube.

Procedure :

- Take about 3 ml of ethanol in a test tube.
- Add 5% solution of alkaline KMnO_4 drop by drop into this solution.
- Observe the colour of alkaline KMnO_4 after adding initially as well as finally.

Observation : The colour of KMnO_4 gets discharged in the beginning. When excess of KMnO_4 is added, the colour of KMnO_4 does not disappear because whole of ethanol gets oxidised to ethanoic acid.



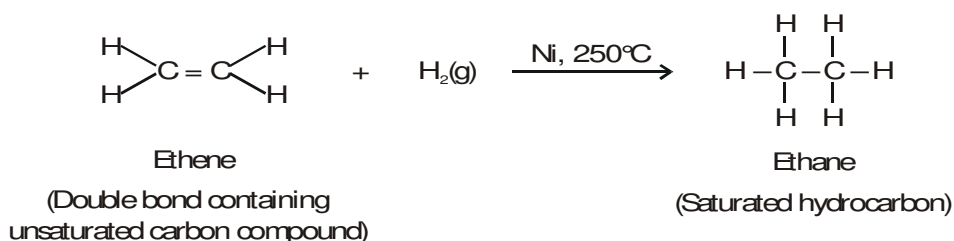
ADDITION REACTION :

All unsaturated hydrocarbons (unsaturated carbon compounds) react with a molecule like H_2 , X_2 , H_2O etc. to form another saturated compounds are called **addition reactions**.

Unsaturated hydrocarbons add hydrogen, in the presence of catalysts, such as nickel or palladium to give saturated hydrocarbons.

Note : Catalysts are substance that cause a reaction to occur or proceed at a different rate without the reaction it say being affected.

- Addition of hydrogen to ethene :**

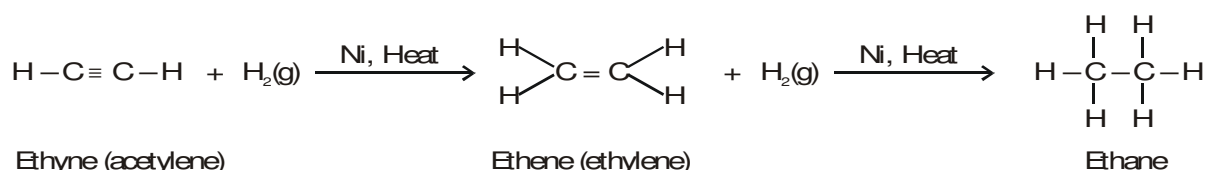


- Q. Which of the following hydrocarbons undergo addition reactions : C_2H_6 , C_3H_8 , C_3H_6 , C_2H_2 and CH_4 .

[NCERT]

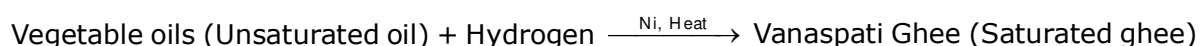


● **Addition of hydrogen to ethyne :**



● Addition of hydrogen to a unsaturated carbon compound is called **hydrogenation reaction**.

Certain vegetable oils such as ground nut oil, cotton seed oil and mustard oil, contain double bonds (C = C) and are liquids at room temperature. Because of the unsaturation, the vegetable oils undergo hydrogenation, like alkenes, to form saturated products called **vanaspati ghee**. Which is semi-solid at room temperature.



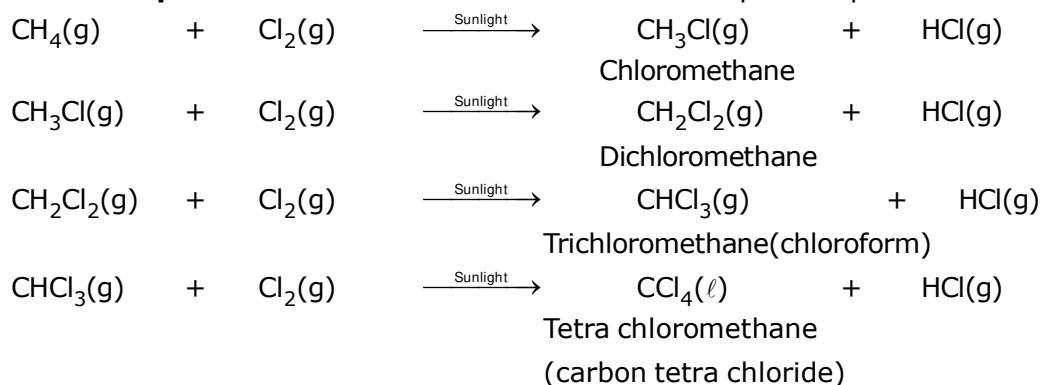
- Q. What is hydrogenation? What is its industrial application? [NCERT]
- Q. If a molecule Y contain two – C = C – double bonds, then how many moles of H₂ are required for complete hydrogenation of one mole of Y? [NCERT]
- Q. Write the industrial application of hydrogenation. [NCERT]

SUBSTITUTION REACTIONS :

The reactions in which one or more hydrogen atoms of a hydrocarbon are replaced by some other atoms or groups are called **substitution reaction**.

Example :

Methane reacts with chlorine (or bromine) in the presence of sunlight and undergo substitution reaction. It is called **photochemical reaction** because it takes place in presence of sunlight.



- Q. Why is the conversion of ethanol to ethanoic acid an oxidation reaction? [NCERT]
- Q. A mixture of oxygen and ethyne is burnt for welding. Can you tell why a mixture of ethyne and air is not used? [NCERT]

⇒ **SOME IMPORTANT CARBON COMPOUNDS :**

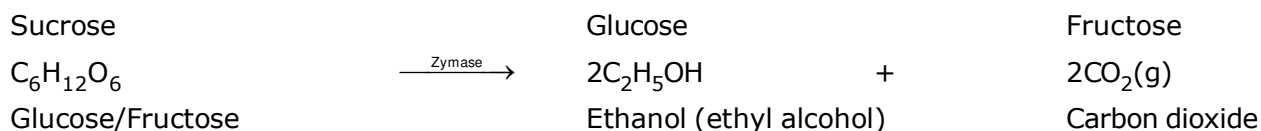
⇒ **ETHANOL (ETHYL ALCOHOL, C₂H₅OH) :**

Ethanol is the second member of the homologous series of alcohols.

Preparation : By the fermentation of carbohydrates (sugar or starch).

Ethanol is prepared on commercial scale by fermentation of sugar. Fermentation is allowed to take place at 298 – 303 K in the absence of air. This is ethanol (ethyl alcohol) gets oxidised to ethanoic acid (acetic acid) in the presence of air.





PHYSICAL PROPERTIES

- **Physical state / colour and odour :** Pure ethanol is a colourless liquid having a pleasant smell and a burning taste.
- **Boiling and Freezing points :** It is a volatile liquid with a boiling point of 78.1°C , and freezing point is -118°C .
- **Density :** Ethanol is lighter than water as its density is 0.79 g ml^{-1} at 293 K .
- **Solubility :** Ethanol is miscible with water in all proportions, due to the formation of hydrogen bonds with water molecules.
- **Conductivity :** Ethanol is a covalent compound and does not ionise easily in water, hence it is a neutral compound.
- **Action on Litmus :** Ethanol is a neutral compound. So, it has no effect on the colour of litmus.

⇒ CHEMICAL PROPERTIES OF ETHANOL :

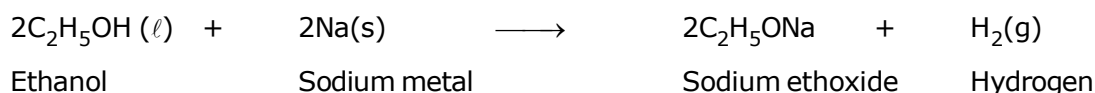
- **Combustion (or burning) :** Ethanol is highly inflammable liquid and readily burn in air with blue flame to form water vapour, carbon dioxide and evolving heat. Thus, combustion of ethanol is an exothermic reaction.



Q. Carbon and its compounds are used as fuels. Give its main reason.

[NCERT]

- **Reaction with sodium metal :** Ethanol reacts with sodium metal to produce sodium ethoxide and hydrogen gas is evolved.



Activity : To study the reaction of ethanol with sodium metal.

Materials : Ethanol, dry piece of sodium metal test tube.

Procedure :

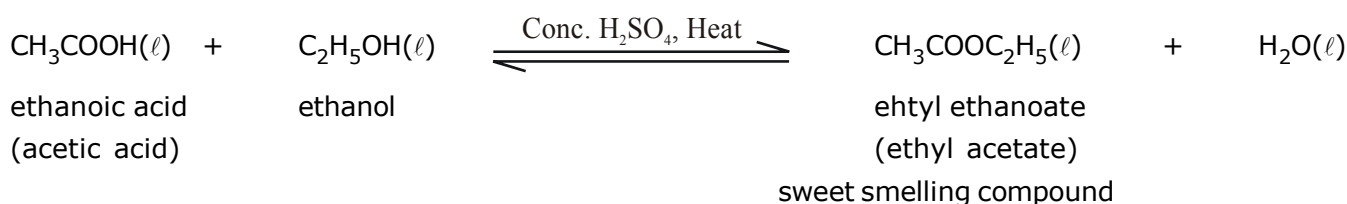
- Take ethanol in a test tube.
- Add a dry piece of sodium metal.
- Bring a burning matchstick near the gas evolved to test it and record observation.

Observation : The gas burns in air with a pop sound which is the characteristics of hydrogen gas.

Conclusion : Alcohol react with sodium metal to liberate hydrogen gas.

- **Reaction with ethanoic acid (Esterification reaction) :**

The reaction in which an alcohol reacts with acetic acid in the presence of conc. H_2SO_4 to form an ester is called **esterification**.

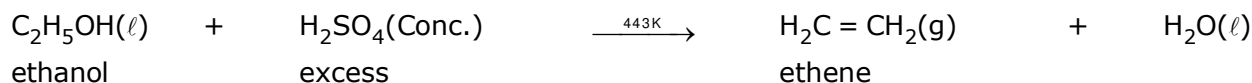


Note : Ester are sweet-smelling compounds and are used for making perfumes.



- **Reaction with conc. sulphuric acid (Dehydration) :**

Ethanol when heated with excess of concentrated sulphuric acid at 443 K, gets dehydrated to give ethene.



Note : The concentrated sulphuric acid can be regarded as a dehydrating agent which remove water from ethanol.

Uses of ethanol :

- Ethanol is present in alcoholic beverages such as beer, wine, whisky.
- As a solvent for paints, varnishes-dyes, cosmetics, perfumes, soaps and synthetic rubber etc.
- Ethanol is used in cough syrups, digestive syrups and tonics.
- A mixture of 80% rectified spirit and 20% petrol is called **power alcohol**. It is used as fuel in cars and aeroplanes.
- A mixture of ethanol and water has lower freezing point than water this mixture is known as **antifreezing** and is used in radiators of vehicles in cold countries and at hill stations.
- As an antiseptic to sterilize wounds and syringes in hospitals.
- For the manufacture of terylene and polythene.
- As a preservative for biological specimens.
- Ethyl alcohol is used as hypnotic (induces-sleep).

Harmful effects of Alcohols :

- Consumption of small quantities of dilute ethanol causes drunkenness. Even though this practice is condemned, it is a socially widespread practice. However, intake of even a small quantity of pure ethanol (called **absolute alcohol**) can be lethal. Also long-term consumption of alcohol leads to many health problems.
- When large quantities of ethanol are consumed, it tends to slow metabolic processes and to depress the central nervous system. This results in lack of coordination, mental confusion, drowsiness, lowering of normal inhibitions and finally stupor (unconscious state of wild)
- Drinking of alcohol over a long period of time damages liver.

Denatured Alcohol :

Ethanol to which certain poisonous and nauseating substances like methyl alcohol, pyridine etc. have been added is termed **denatured alcohol**.

Note : To prevent the misuse of ethanol (Alcohol), industrial alcohol is coloured blue so that it can be recognised easily.

Harmful effects of denatured alcohol :

- Methanol is highly poisonous compound for human beings. Methanol when taken, even in small amount, can cause death.
- Methanol gets oxidised to methanal in the liver, which causes coagulation of protoplasm.
- Methanol also effects the optic nerve and cause blindness.

⇒ **ETHANOIC ACID (ACETIC ACID) CH₃COOH :**

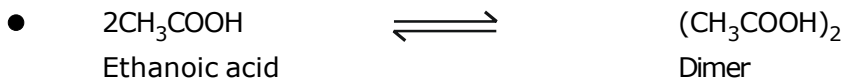
- Ethanoic acid is commonly called acetic acid and belongs to the homologous series of carboxylic acid and is represented as CH₃COOH.
- 5-8% solution of acetic acid in water is called **vinegar** and is used for preserving foods like *sausage*, pickles.

Physical properties :

- At ordinary temperature, ethanoic acid is a colourless liquid with a strong pungent smell and sour taste.
- Its boiling point is 391 K and its density at 273 K is 1.08 (heavier than water).
- It is miscible with water due to the formation of hydrogen bonds with water molecules.



- On cooling at 289.6 K, it turns in ice-like crystals, hence named as ***glacial acetic acid***.
- It dissolves sulphur, iodine and many other organic compounds.
- It dimerise when dissolved in benzene.



Activity : To determine pH of acetic acid and hydrochloric acid.

Material : Acetic acid (1M), HCl (1M), blue litmus paper, universal indicator.

Procedure : Take two strips of blue litmus paper.

- Put a few drops of HCl on one of them and few drops of acetic acid on the other.
- Observe the change in colour.
- Take 1 ml of acetic acid in a test tube and add a few drops of universal indicator.
- Take 1 ml of HCl in a test tube and add few drops of universal indicator.

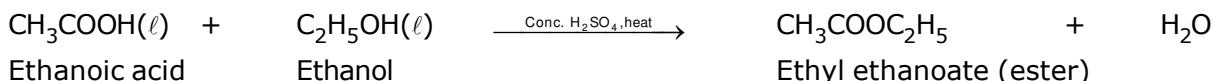
Observation : Both acetic acid and HCl turn blue litmus red showing that they are acidic in nature. pH of acetic acid and HCl are not equal.

Conclusion : HCl is strong acid than CH_3COOH , therefore, pH of HCl will be lower than that of acetic acid.

CHEMICAL PROPERTIES

- **Reaction with alcohols (Esterification reaction) :**

Ethanoic acid reacts with ethanol in the presence of conc. H_2SO_4 to form ethyl ethanoate which is an ester.

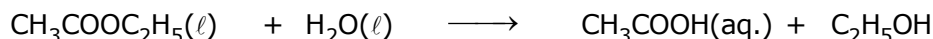


the reaction of carboxylic acid with an alcohol to form an ester is called "**esterification**".

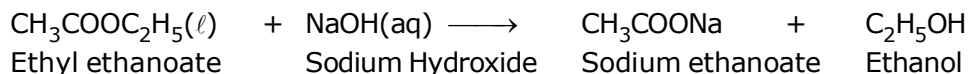
Note : Ester can be hydrolysed in the presence of an acid or a base to give back the parent carboxylic acid and the alcohol.

Example :

- (i) Ethyl ethanoate on acid hydrolysis gives ethanoic acid and ethanol.



- (ii) Hydrolysis of ester in the presence of base (alkali) is called "**Saponification reactions**".



Note : Alkaline hydrolysis of higher esters is used in the manufacture of **soaps**.

Activity : To study the esterification process using ethanol and acetic acid.

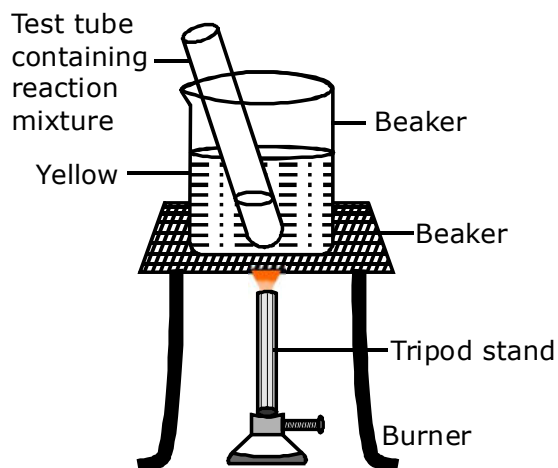
Materials : Beaker, water, test tube, ethanol, acetic acid.
Conc. H_2SO_4 etc.

Procedure : Take 2ml of ethanol in a test tube.

- Add 2ml of ethanoic acid (acetic acid) in to it.
- Add few drops of conc. H_2SO_4 .
- Warm it in a beaker containing water.

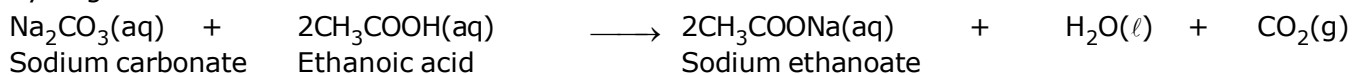
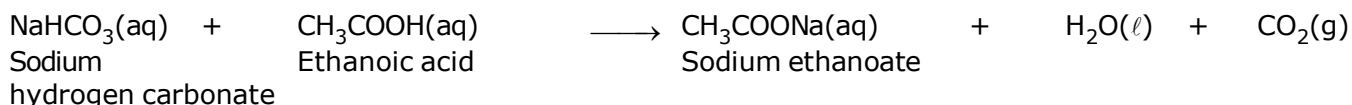
Observation : Pleasant fruity smelling compound (called ester) is formed.

Conclusion : Acetic acid reacts with alcohol in presence of conc. H_2SO_4 which act as a dehydrating agent to form ester.



Reaction with sodium carbonate and sodium hydrogen carbonate :

Ethanoic acid decomposes sodium hydrogen carbonate and sodium carbonate with a rapid evolution of carbon-dioxide gas.



Note ; Reactions of ethanoic acid with NaOH, NaHCO₃, Na₂CO₃ and active metals show that the hydrogen present in the carboxyl (–COOH) group is acidic in nature.

Activity : To study the reaction of carboxylic acid with sodium carbonate and sodium hydrogen carbonate.

Material : Ethanoic acid, Sodium carbonate, Sodium hydrogen carbonate.

Procedure :

- Take 1g of Na₂CO₃ and add 2ml of ethanoic acid into it.
- Pass the gas formed through lime water and note down the observation.
- Repeat the same procedure with sodium hydrogen carbonate and record observation.

Observation : Brisk effervescence due to carbon dioxide formed which turns lime water milky.

Conclusion : Acetic acid react with Na₂CO₃ and NaHCO₃ to liberate CO₂ gas.

USES OF ETHANOIC ACID :

- Ethanoic acid is used in the manufacture of various dyes, perfumes and rayon.
- It is used for making vinegar.
- It is used for making white lead [2PbCO₃ . Pb(OH)₂] which is used in white paints.
- Its 5% solution is bactericidal (destroys bacteria).
- It is used in preparation of cellulose acetate which is used for making photographic film.
- It is used for coagulation of the latex.
- It is used for preparation of 2, 4-dichloro phenoxy ethanoic acid which is used as **herbicide**.
- Aluminium acetate and chromium acetate are used as mordants in dyeing and water proofing of fabrics.

Q. How would you distinguish experimentally between an alcohol and a carboxylic acid? **[NCERT]**

Q. What are oxidising agents? **[NCERT]**

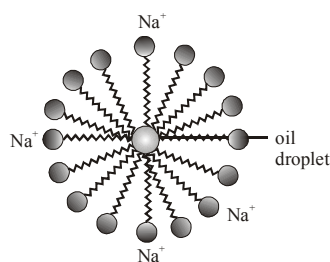
Q. How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties? **[NCERT]**

SOAP AND DETERGENTS :

Soap and detergents are substances which are used for cleaning. There are two types of detergents :

1. Soap
2. Synthetic detergents

Soap : A soap is the sodium or potassium salt of a long-chain fatty acids (carboxylic acid or glycerol).

Activity :

Formation of micelles

Take about 10mL of water each in two test tubes.

Add a drop of oil (cooking oil) to both the test tubes and label them as A and B.



To test tube B, add a few drops of soap solution. Now shake both the test tubes vigorously for the same period of time.

Can you see the oil and water layers separately in both the test tubes immediately after you stop shaking them.

Leave the test tubes undisturbed for some time and observe. Does the oil layer separate out? In which test tube does this happen first?

This activity demonstrate effect of soap in cleansing as we know that most of the dirt is oily in nature and oil does it dissolve in water.

But know the question arise what are soap? What are the detergent which one is more effect. How the work. Soap is sodium or potassium salt a long chain fatty acid (Carboxylic acid or Glycerol)

A soap has large non ionic hydrocarbon group and an ionic group. COONa .

Ex.of soap are :

- (1) Sodium stearate ($\text{C}_{17}\text{H}_{35}\text{COONa}$) (2) Sodium plamitate ($\text{C}_{15}\text{H}_{31}\text{COONa}$)

Soap are basic in nature so soap solution turn red litmus to blue.

Preparation of Soap :

The soap is prepared by heating animal fats or vegetable oils (olive oils, castor oil or palm oil) with sodium hydroxide or potassium hydroxide.

The process of formation of soap by the hydrolysis of fat or oil with alkali is called **saponification**.

Oil or Fat + Sodium hydroxide \rightarrow Soap + glycerol

Structure :

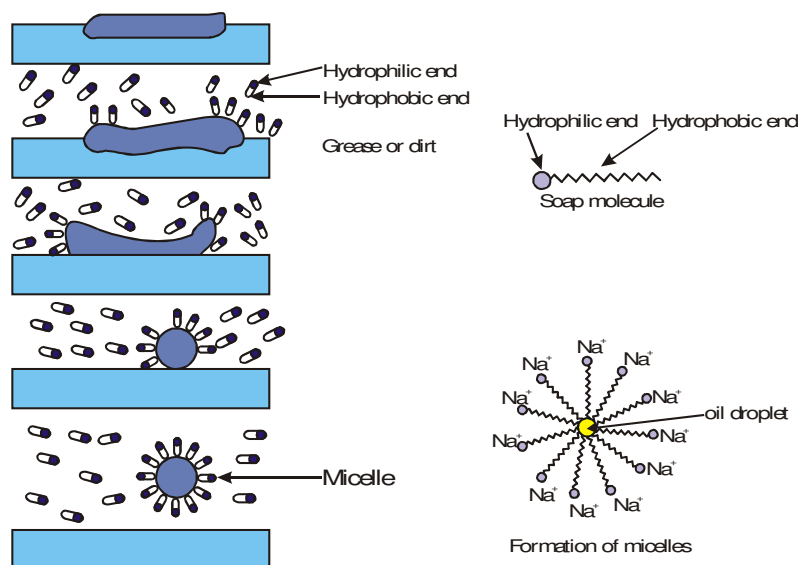
● A soap molecule contains two parts that interact differently with water, one part is a long hydrocarbon (non-polar) chain, and other belongs to the $-\text{COONa}$ group (Hydrophillic).

A soap molecule may be represented as :



Cleansing action of soap:

The molecules of soap are sodium or potassium salts of long chain carboxylic acids. The ionic end of soap dissolves in water while the carbon chain dissolves in oil. The soap molecules, thus form structures called micelles where one end of the molecules is towards the oil droplet while the ionic end faces outside. This form an emulsion in water. The soap micelle thus helps in dissolving the dirt in water and we can wash out clothes clean.



Effect of soap in cleaning



- Q.** Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also? [NCERT]
- Q.** Explain the mechanism of the cleaning action of soaps. [NCERT]

Activity : Take two clean test tubes and label them as 'A' and 'B'. Now put 10ml of hard water in each of the two test tubes. Add five drops of soap solution in test tube 'A' and five drops of detergent solution in test tube 'B'. Shake the two test tubes for the same period and observe if both the test tubes have the same amount of foam. Find out in which of the two test tubes a curdy white mass is formed. In which test tube do you get more foam ?

We get more foams in test tube

A white curdy precipitate is formed in test tube.....

Result (Conclusion) : Soaps are not effective in acidic medium.

When soaps is used for washing clothes with hard water, a large amount of soap is wasted in reacting with the calcium and magnesium ions of hard water to form an insoluble precipitate called scum, before it can be used for the real purpose of washing soap. A large amount of soap is needed for washing clothes. When the water is hard.

Activity :

Take two test tubes with a about 10 mL of hard water in each.

Add five drops of soap solution to one and five drops of detergent solution to the other.

Shake both test tubes for the same period

Do both test tubes have the same amount of foam ?

In which test tube is a curdy solid formed ?

Observation :

Test tube in whichis present contain more amount of foam.

Curdy solids is form in the test tube containing

Conclusion : Detergents have better cleasing action than soap. Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. Thus, they remain effective in hard water. Detergents are usually used to make shampoos and products for cleaning clothes.

- Q.** What change will you observe if you test soap with litmus paper (red and blue)? [NCERT]
- Q.** Would you be able to check if water is hard by using a detergents ?
- Q.** People use a variety to methods to wash clothes. Usually after adding the soap, they 'beat' the clothes on a stone, or beat it with a paddle, scrub with a brush or the mixture is agitated in a washing machine. Why is agitation necessary to get clean clothes ?

DIFFERENCES BETWEEN SOAPS AND SYNTHETIC DETERGENTS :

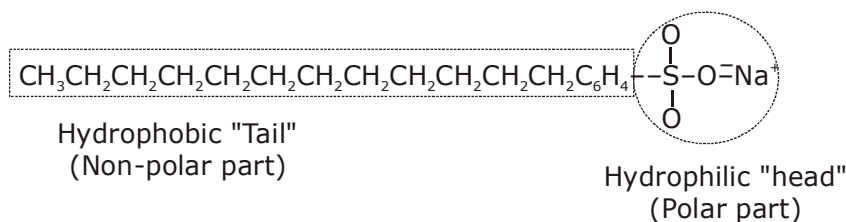
Soaps		Synthetic detergents	
1	Soaps are sodium salts of long chain fatty acid (carboxylic acids)	1	Synthetic detergents are the sodium salts of long-chain benzene sulphonc acids or the soidum salt of a long - chain alkyl hydrogen sulphate
2	The ionic part of soap is $\text{-COO}^-\text{Na}^+$	2	The ionic part in a synthetic detergents is $\text{-SO}_3^-\text{Na}^+$
3	They are prepared from animal fats or plant based oils.	3	The are prepared from hydrocarbons extracted from coal or petroleum
4	Their efficiency decreases in hard water	4	Their efficiency is unaffected in hard water.
5	Soaps take more time to dissolve in water.	5	Synthetic detergents dissolve faster than soaps in water
6	They are biodegradable	6	Some synthetic detergents are not biodegradable
7	Examples: Sodium sterate, sodium palmitate	7	Example: Sodium lauryl sulphate, sodium dodecyl benzene sulphonate



You will observe that the amount of foam in the two test tubes is different. The foam is formed to a greater extent in test tube 'B' (containing detergent solution), while formation of a curdy white mass will be observed in test tube 'A'. This activity clearly indicates that detergents can be used for cleansing purpose, even with hard water.

SYNTHETIC DETERGENTS

- Synthetic detergents are called soapless soap because they are not prepared from **fatty acid** and **alkali**.
- Synthetic detergents are sodium salts of sulphonic acids, i.e. detergents contain a sulphonic acid group ($-\text{SO}_3\text{H}$), instead of a carboxylic acid group ($-\text{COOH}$), on one end of the hydrocarbon chain.



Properties of synthetic detergents :

- Synthetic detergents do not react with the ions present in hard water. Hence, synthetic detergents have no problem in forming lather with hard water, i.e. their efficiency is not affected by hard water.
- Synthetic detergents can be used even in acidic solution and sea water, whereas soap cannot be used in the acidic solution (due to precipitation of free acids)
- Synthetic detergents do not form insoluble salts of calcium or magnesium with hard water. Hence, lesser amounts of synthetic detergents are required for washing.

Washing powder :

- Washing powders used for washing clothes contain only about 15 to 30 percent detergents by mass. The remaining part is made of the following.
 - (i) Sodium sulphate and sodium silicate which keep the powder dry.
 - (ii) Sodium tripolyphosphate or sodium carbonate which maintains alkalinity for removing dirt.
 - (iii) Carboxymethylcellulose (CM-Cellulose) which keep the dirt particle suspended in water.
 - (iv) Sodium perborate (a mild bleaching agent) which impart whiteness to the materials (clothes, etc.) being washed.

REVISION

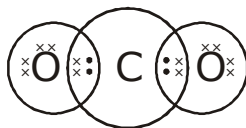
- Carbon is versatile element that forms the basis of all living things.
- Carbon can form a vast variety of compounds because of its tetravalency and the property of catenation.
- Covalent bonds are formed between two similar or different atoms by sharing electrons in their valence shell, such that both of them can achieve the structure of nearest noble gas.
- Carbon forms covalent bonds with itself as well as atoms of hydrogen, oxygen, nitrogen, sulphur and halogens.
- Carbon can form compounds having a straight chain between carbon atoms with a single bond, or double bond or triple bond. It can also form compounds with branched chains and closed chains.
- homologous series of carbon compounds is a group of carbon compounds having the same functional group with the same general formula.
- The functional groups such as alcohols, aldehydes, ketones, carboxylic acids and halogens impart characteristic properties to the carbon compounds.
- Carbon and its compounds are the major sources of fuels.
- Ethanol and ethanoic acid are most important compounds of carbon in our daily life.
- The soaps and detergents have cleansing action, because of the presence of hydrophobic and hydrophilic groups in their molecules, which help in emulsifying oil, and hence, in the removal of dirt.



NCERT QUESTIONS WITH SOLUTIONS

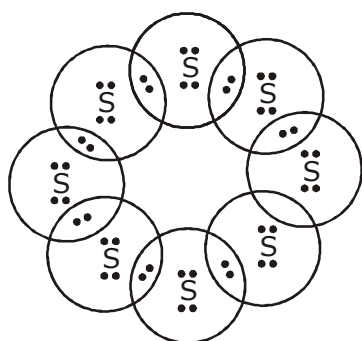
Q.1 What would be the electron dot structure of carbon dioxide which has the formula CO_2 ?

Ans. The electron dot formula of CO_2 is given below:

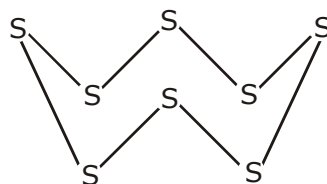


Q.2 What would be the electron dot structure of a molecule of sulphur which is made up of eight atoms of sulphur? [Hint: The eight atoms of sulphur are joined together in the form of a ring].

Ans. The electron dot structure of a molecule of sulphur which is made of eight atoms of sulphur is given below: Electron-dot structure of sulphur molecules, S_8 .



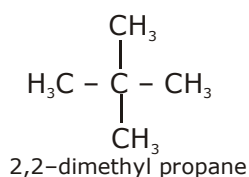
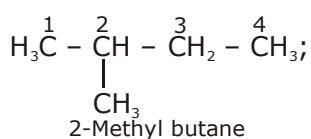
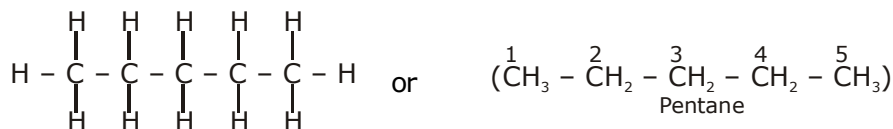
Ring structure of S_8 molecule



Crown Shape of S_8 molecule

Q.3 How many structural isomers can you draw for pentane?

Ans. Three structural isomers can be drawn for pentane:

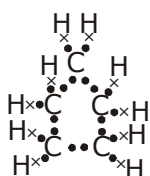


Q.4 What are the two properties of carbon which lead to the huge number of carbon compounds we see around us?

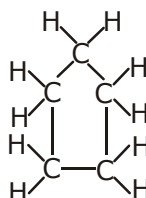
Ans. The two properties of carbon are its tetra covalency and the catenation which lead to huge number of carbon compounds we see around us.

Q.5 What will be the formula and electron dot structure of cyclopentane?

Ans. The formula of cyclopentane will be C_5H_{10} . Its electron dot structure will be as shown below



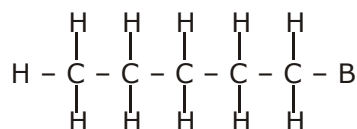
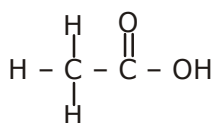
or



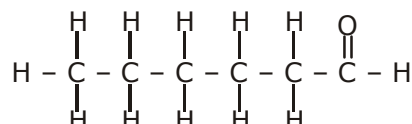
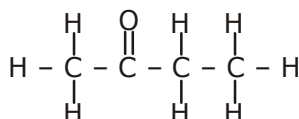
CARBON & ITS COMPOUNDS

Q.6 Draw the structures for the following compounds: (i) Ethanoic acid (ii) Bromopentane* (iii) Butanone (iv) Hexanal. *Are structural isomers possible for bromopentane?

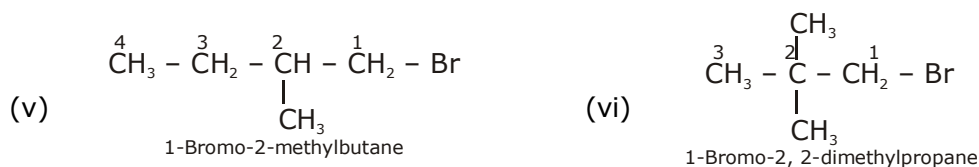
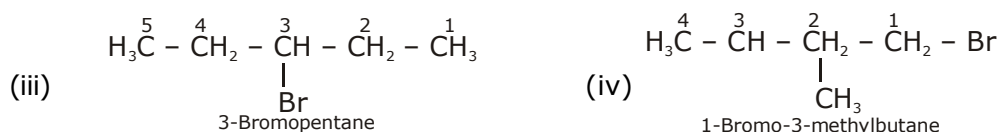
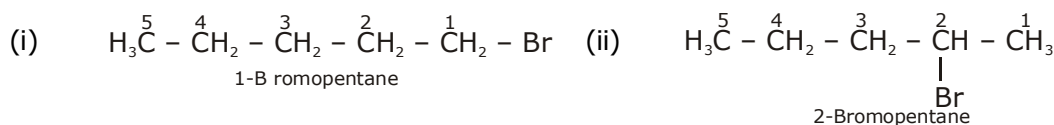
Ans. (i) Ethanoic acid (ii) Bromopentane



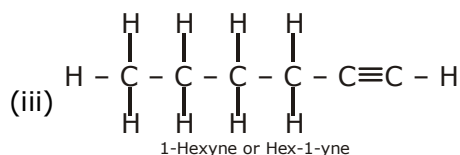
(iii) Butanone (iv) Hexanal



Bromopentane has a chain of five carbon atoms. It can exist in a number of forms which are structural isomers.

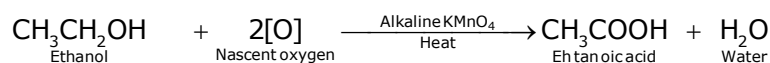


Q.7 How would you name the following compounds?



Q.8 Why is the conversion of ethanol to ethanoic acid an oxidation reaction?

Ans. The conversion of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) to ethanoic acid (CH_3COOH) is called an oxidation reaction because oxygen is added to it during this conversion.



Q.9 The mixture of oxygen and ethyne is burnt for welding. Can you tell why a mixture of ethyne and air is not used?

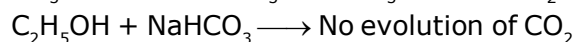
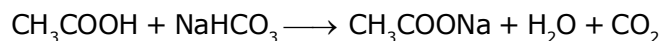
Ans. A mixture of ethyne and air is not used for welding because burning of ethyne in air produces a sooty flame due to incomplete combustion which is not enough to melt metals for welding.

When ethyne is burnt in oxygen, large quantity of heat along with light is produced. The heat evolved can be used for gas welding which is usually carried to weld small broken pieces of articles made up of iron. Air mainly contains a mixture of nitrogen (4 parts) and oxygen (1 part). As we know, nitrogen gas does not support combustion. This means that in air, only oxygen will help in the combustion of ethyne. Therefore, it is always better to use oxygen for the combustion of ethyne.

Q.10 How would you distinguish experimentally between an alcohol and a carboxylic acid?

Ans. Take the samples of alcohol and carboxylic acid in different test tubes and add sodium hydrogen carbonate in both the test tubes.

The test tube from which the effervescence evolves is carboxylic acid. The effervescence is due to the evolution of carbon dioxide.



Q.11 What are oxidising agents?

Ans. An oxidising agent is one which oxidizes other substances by providing oxygen or removing hydrogen. The commonly used oxidising agents are: Ozone, bromine water, a mixture of potassium dichromate and sulphuric acid or a mixture of potassium permanganate and sulphuric acid.

Q.12 Would you be able to check if water is hard by using a detergent?

Ans. No, we cannot check the presence of hard water by using a detergent. Actually detergents produce foam in any type of water; whether hard or soft. Therefore, a distinction between the two cannot be made. However, soaps can be used for this purpose.

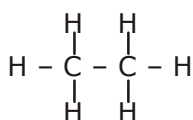
Q.13 People use a variety of methods to wash clothes. Usually after adding the soap, they 'beat' the clothes on a stone, or beat it with a paddle, scrub with a brush or the mixture is agitated in a washing machine. Why is agitation necessary to get clean clothes?

Ans. The molecules of soap are sodium or potassium salts of long-chain carboxylic acids. The ionic end of soap dissolves in water while the carbon chain dissolves in oil. The soap molecules, thus form structures called micelles. When cloth is agitated, the micelles containing oily or greasy dirt particles get removed from the surface of dirty cloth and into water and clothes get cleaned.

Q.14 Ethane with the molecular formula C_2H_6 has

(A) 6 covalent bonds (B) 7 covalent bonds (C) 8 covalent bonds (D) 9 covalent bonds

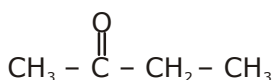
Ans. (B) [Hint: The structure of C_2H_6 is:]



Q.15 Butanone is a four-carbon compound with the functional group

(A) carboxylic acid (B) aldehyde (C) ketone (D) alcohol

Ans. (C) [Hint: The structure of butanone is:]

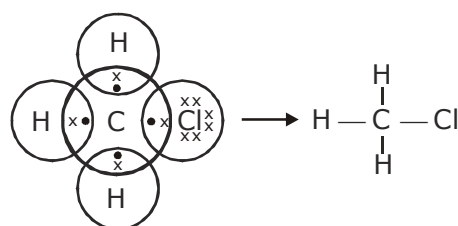


- Q.16** While cooking, if the bottom of the vessel is getting blackened on the outside it means that
 (A) the food is not cooked completely (B) the fuel is not burning completely
 (C) the fuel is wet (D) the fuel is burning completely

Ans. (B) The fuel is not burning completely.

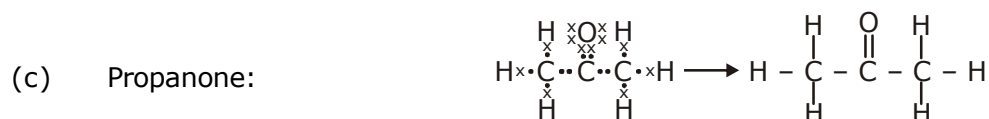
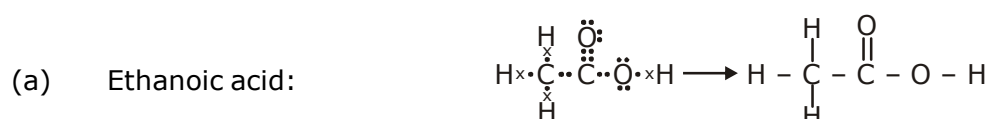
- Q.17** Explain the nature of the covalent bond using the bond formation in CH_3Cl .

Ans. Covalent bond is formed by sharing the electrons between two atoms:



- Q.18** Draw the electron dot structure for
 (a) ethanoic acid (b) H_2S (c) propanone (d) F_2

Ans. The electron dot structures are given below:



- Q.19** What is an homologous series? Explain with an example.

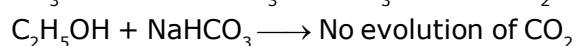
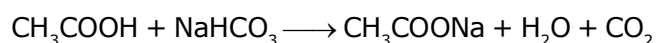
Ans. A series of compounds in which the same functional group substitutes for hydrogen in a carbon chain is called homologous series. These differ by $-\text{CH}_2$ unit.

Example: Homologous series of alcohols: CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, $\text{C}_3\text{H}_7\text{OH}$. These differ by $-\text{CH}_2$ unit.

- Q.20** How can ethanol and ethanoic acid be differentiate on the basis of their physical and chemical properties?

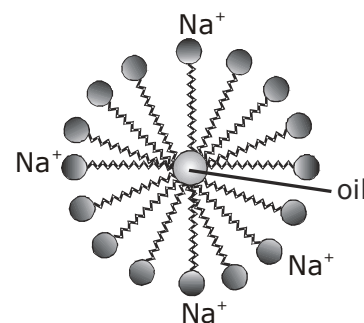
Ans. Differentiation of ethanol and ethanoic acid on the basis of their physical properties. Ethanol has a pleasant odour whereas Ethanoic acid smells like vinegar. Differentiation of ethanol and ethanoic acid on the basis of their chemical properties:

Take the samples of ethanol and ethanoic acid in different test tubes and add sodium hydrogen carbonate in both the test tubes. The test tube from which the effervescence evolves is ethanoic acid. The effervescence is due to the evolution of carbon dioxide.



Q.21 Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also?

Ans. Soap are sodium or potassium salts of long-chain carboxylic acids. The acid end of soap dissolves in water while the carbon chain dissolves in oil. When soap is added to the water, the hydrophilic end (acid end) will align along the surface of water and the hydrophobic tail (carbon chain) remains out of water. The cluster of molecules in which hydrophobic tail are in the interior of cluster and the ionic ends are on the surface of cluster is called micelle. The soap micelles thus helps in dissolving the dirt in water and we can wash our clothes clean. No, micelle will not be formed in their solvents such as ethanol.

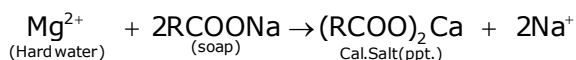
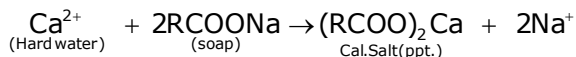


Q.22 Why are carbon and its compounds used as fuels for most applications?

Ans. Carbon and its compounds are used as fuel because when they are burnt, they give large amount of energy in the form of heat.

Q.23 Explain the formation of scum when hard water is treated with soap.

Ans. Hard water contains soluble salts of sulphates and chlorides of calcium and magnesium. When soap is used to clean using hard water calcium and magnesium present in hard water produce an insoluble substance called scum that remains after washing the cloth with water.



Q.24 What change will you observe if you test soap with litmus paper (red and blue)?

Ans. When we test soap with red and blue litmus paper red will turn blue but blue will remain as blue.

Q.25 What is hydrogenation? What is its industrial application?

Ans. Addition of hydrogen to an unsaturated hydrocarbon in presence of catalyst such as palladium or nickel to give saturated hydrocarbons is called hydrogenation. The process is used to make healthy vegetable oils in industry.

Q.26 Which of the following hydrocarbons undergo addition reactions: C_2H_6 , C_3H_8 , C_3H_6 , C_2H_2 and CH_4 .

Ans. Unsaturated hydrocarbons undergo addition reactions. The following are the unsaturated hydrocarbons amongst the given examples: C_3H_6 and C_2H_2 .

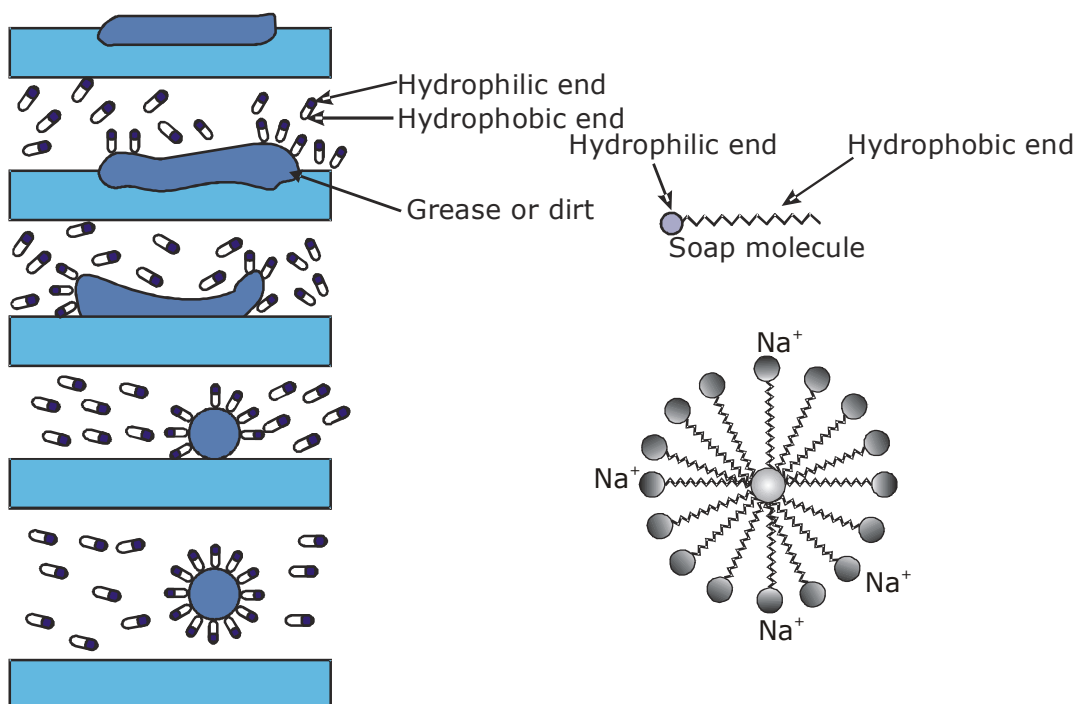
Q.27 Give a test that can be used to differentiate chemically between butter and cooking oil.

Ans. Take butter and cooking oil in two separate test tubes. Add bromine water to each test tube. The one containing cooking oil will decolourise the light brown colour of bromine water, i.e., bromine water will become colourless. The colour of Bromine water will remain as such in other test tube.



Q.28 Explain the mechanism of the cleaning action of soaps.

Ans. Cleaning action of soap has been explained with the help of figure. Soaps are molecules in which the two ends have differing properties, one is hydrophilic, that is it dissolves in water, while the other end is hydrophobic, that is it dissolves in hydrocarbons. When soap is at the surface of water the hydrophobic 'tail' of soap will not be soluble in water and the soap will align along the surface of water with the ionic end in water and the hydrocarbon 'tail' protruding out of water. Inside water, these molecules have a unique orientation that keeps the hydrocarbon portion out of the water. This is achieved by forming clusters of molecules in which the hydrophobic tails are in the interior of the cluster and the ionic ends are on the surface of the cluster. This formation is called a micelle. Soap in the form of a micelle is able to clean, since the oily will be collected in the centre of the micelle. The micelles are large enough to scatter light. Hence a soap solution appears cloudy.

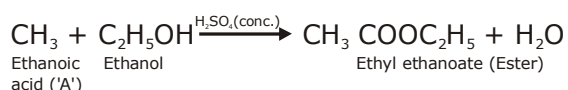


EXERCISE – I
BOARD PROBLEMS

Q.1 An organic compound 'A' has molecular formula $C_2H_4O_2$ and is acidic in nature. On heating with alcohol and conc. sulphuric acid, vapours with pleasant or fruity smell are given out. What is this chemical compound 'A' and what is the chemical equation involved in the reaction ?

(CBSE All India 1999)

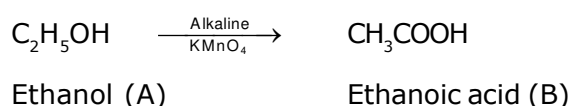
Ans. The compound 'A' with molecular formula $C_2H_4O_2$ is ethanoic acid (acetic acid). Upon heating with ethanol (ethyl alcohol) and concentrated sulphuric acid, ethyl ethanoate (ethyl acetate) is formed as the product. It is an ester with pleasant or fruity smell. The reaction is known as esterification reaction.



Q.2 An organic compound 'A' is a constituent of antifreeze and has the molecular formula C_2H_6O . Upon reaction with alkaline KMnO_4 , the compound 'A' is oxidised to another compound 'B' with formula $C_2H_4O_2$. Identify the compounds 'A' and 'B'. Write the chemical equation for the reaction which leads to the formation of 'B'.

(CBSE All India 2000 Comptt.)

Ans. The compound 'A' is ethanol and with alkaline KMnO_4 , it is oxidised to ethanoic acid 'B'. The chemical equation for the reaction is :



Q.3 Name the functional groups present in the following compounds :

- $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—OH}$
- $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—COOH}$
- $\text{CH}_3\text{—CH}_2\text{—CHO}$
- $\text{CH}_3\text{—CO—CH}_2\text{—CH}_3$

Ans. (i) —OH (ol)
(ii) —COON (oic acid)
(iii) —CHO (al)
(iv) —CO— (one)

Q.4 Write the formulae of the compounds and name the functional groups present in each of them

- Ethanoic acid
- Propanone

(iii) Nitromethane **(C.B.S.E. Delhi 2005)**

Ans. (i) Ethanoic acid : CH_3COOH (oic acid)

(ii) Propanone : CH_3COCH_3 (one)

(iii) Nitromethane : CH_3NO_2 (nitro)

Q.5 Name the enzyme which converts :

(i) milk into curd (yogurt)

(ii) cane sugar into glucose and fructose

(iii) glucose into ethanol.

(C.B.S.E. Foreign 2005)

Ans. (i) Lactase converts milk into curd

(ii) Invertase converts cane sugar (sucrose) into glucose and fructose

(iii) Zymase converts glucose into ethanol.

Q.6 (i) Name the gas evolved during fermentation process. **(C.B.S.E. Delhi 2006)**

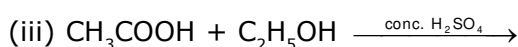
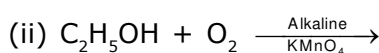
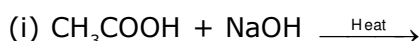
(ii) List the two products formed when enzyme invertase acts on sugar present in molasses.

Ans. (i) CO_2 gas is evolved accompanied by brisk effervescence.

(ii) Glucose and fructose are the products when enzyme invertase acts on sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) present in molasses.

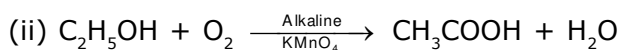
Q.7 Complete the following equations and write the names of the products formed.

(C.B.S.E. Delhi 2007)



Ans. (i) $\text{CH}_3\text{COOH} + \text{NaOH} \xrightarrow{\text{Heat}} \text{CH}_3\text{COONa} + \text{H}_2\text{O}$

Ethanoic acid Sod. ethanoate



Ethanol Ethanoic acid



Q.8 Name the organic compound present in vinegar. Write a chemical equation which represents the commercial method for the preparation of this compound from methanol.

(C.B.S.E. All India 2007)



Ans. The organic compound present in vinegar is ethanoic acid also called acetic acid. For its commercial preparation.

Q.9 (a) Why does carbon form compounds by covalent bonding ?

(b) An organic acid 'X' is a liquid which often freezes during winter time in cold countries. It has the molecular formula $C_2H_4O_2$. On warming with ethanol in the presence of a few drops of sulphuric acid, a compound 'Y' with sweet smell is formed.

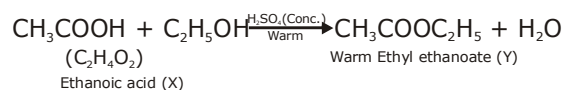
(i) Identify X and 'Y'.

(ii) Write chemical equation for the reaction involved.

(C.B.S.E. Delhi 2008)

Ans. (a) Carbon forms a large number of organic compounds due to the self linking property known as catenation.

(b) The available information suggests that the organic acid X with molecular formula $C_2H_4O_2$ is ethanoic acid (CH_3COOH). It reacts with ethanol in the presence of a few drops of sulphuric acid on warming to give ethyl ethanoate ester with a pleasant smell.



Q.10 Why do covalent compounds have low melting and boiling points ?

(C.B.S.E. All India 2008)

Ans. In covalent compounds, the atoms are linked by covalent bonds formed by electron sharing. Since no ions are present in these, the attractive forces are quite weak. As a result, the covalent compounds have low melting and boiling points.

Q.11 (i) How are carboxylic acids different from mineral acids from ionisation point of view ?

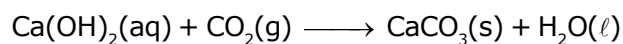
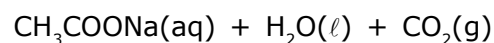
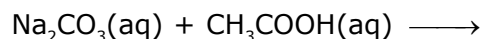
(ii) Describe an activity to find how ethanoic acid reacts with sodium carbonate. Name the gas evolved. How can it be tested ?

(C.B.S.E. All India 2008)

Ans. (i) Carboxylic acids (organic acids) are less ionised in solution as compared to mineral acids (HCl , HNO_3 , H_2SO_4 etc.) Due to this reason, these are weaker acids than the mineral acids.

(ii) Take a small volume of ethanoic acid in a tube. Add a few drops of sodium carbonate (Na_2CO_3) solution prepared in water to the tube.

A colourless gas with brisk effervescence will evolve. When the gas is passed through lime water, it will become milky.



Lime water

(Milky)

Q.12 (a) What is a functional group in a carbon compound ? Identify the functional group present in CH_3COOH and C_2H_5OH .

(b) State the principle on which the cleansing action of soap is based.

(C.B.S.E. Foreign 2008)

Ans. (a) Functional group may be defined as an atom or group of atoms upon which the properties of a particular organic compound are based. Different families differ in the functional groups.

Functional group in CH_3COOH : ($-COOH$)

Functional group in C_2H_5OH : ($-OH$)

(b) The cleansing action of soap is based on its tendency to act as a bridge between water and oil drops containing dirt particles. As a result, oil and water get mixed. They form a stable emulsion also called micelle. This helps in removing oil drops containing dirt particles from clothes. The clothes become clean.

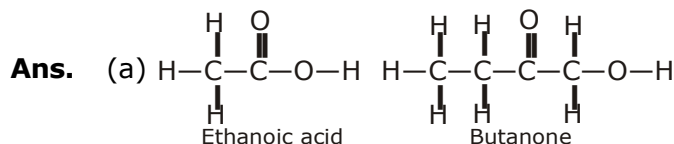
Q.13 (a) Draw the structure of the following compounds

(i) Ethanoic acid

(ii) Butanone.

(b) Why is conversion of ethanol to ethanoic acid considered an oxidation reaction?

(C.B.S.E. Foreign 2008)



(b) When ethanol (C_2H_5OH) changes with ethanoic acid (CH_3COOH)

- There is a decrease in the number of hydrogen atoms by two.

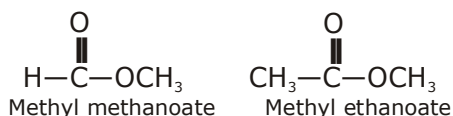
- There is an increase in the number of oxygen atoms by one. Therefore, the conversion represents an oxidation reaction.



- Q.14** (a) What are esters ? How are they formed?
(b) Write two uses of esters ?

(CBSE Foreign 2008)

Ans. (a) Esters are the group of organic compounds which contain the function group ($-\text{COOR}$) called ester group. The value of R may change as $-\text{CH}_3$, $-\text{C}_2\text{H}_5$, $-\text{C}_3\text{H}_7$ etc. A few example of esters are :



Esters are formed as a result of chemical reaction called esterification.

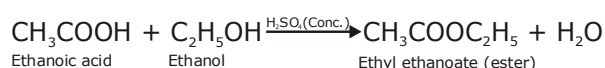
Uses of esters

- Esters have pleasant smell. These are used as flavouring agents and also in perfumes.
- Esters of glycerol known as triglycerides are used in the manufacture of soaps. This reaction is called saponification reaction.

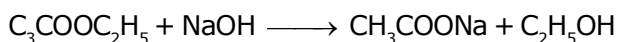
- Q.15** Distinguish between esterification and saponification reactions of organic compounds.

(C.B.S.E. All India 2008)

Ans. (a) In the esterification reaction an acid reacts with alcohol in the presence of conc. H_2SO_4 to form an ester with a pleasant or fruity smell. For example,



Saponification is quite different from esterification because in this case an ester reacts with an alkali (NaOH or KOH) to form salt of acid and alcohol. For example,



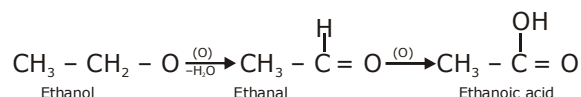
Ethyl ethanoate Sod. ethanoate Ethanol

- Q.16** (a) In organic compounds, which part largely determines the physical and chemical properties. **(CBSE All India, 2008)**

(b) Write chemical equation to represent the reaction of ethanol with acidified solution of potassium dichromate.

Ans. (a) In organic compounds, it is the functional group which largely determines the physical and chemical properties of compounds. Actually, an organic compound is made up of two parts. These are alkyl group and the functional group. Whereas the alkyl group remains the same (size may change) but the functional groups change. These are responsible for the characteristics of the compounds. For example, the properties of alkanols ($-\text{OH}$ is the functional group) are different from those of alkanoic acid ($-\text{COON}$ is the functional group). For more details, consult text part.

(b) Acidified solution of potassium dichromate ($\text{K}_2\text{O}_2\text{O}_7$) forms chromic acid (H_2CrO_4). It releases oxygen to bring about the oxidation of ethanol first to ethanal and then to ethanoic acid.



- Q.17** Give reason for the following:

(a) Air holes of the gas burners have to be adjusted when heated vessels get blackened by the flame.

(b) Use of synthetic detergents causes pollution problems. **(C.B.S.E. Delhi, 2009)**

Ans. (a) In case the vessel where cooking is done gets blackened from outside, this means that combustion is incomplete. As a result, the carbon particles in the form of soot get deposited and the vessel becomes black from outside. In order to check this, oxygen or air supply must be increased. This can be done only by adjusting the air holes of the gas burner.

(b) The pollution problems caused by the synthetic detergents is due to their non-biodegradable nature. These are actually long chain organic compounds which do not break or decompose in water. Naturally, this will result in pollution problems. Some of the detergents are even of toxic nature and will make water unfit for drinking.



EXERCISE – II
PRACTICE PROBLEMS
A. MULTIPLE CHOICE QUESTION

- Q.1** Ethane, with the molecular formula C_2H_6 has
(A) 6 covalent bonds (NCERT)
(B) 7 covalent bonds
(C) 8 covalent bonds
(D) 9 covalent bonds
- Q.2** Butanone is a four-carbon compound with the functional group (NCERT)
(A) Carboxylic acid (B) aldehyde
(C) ketone (D) alcohol
- Q.3** While cooking, if the bottom of the vessel is getting blackened on the outside, it means that (NCERT)
(A) the food is not cooked completely
(B) the fuel is not burning completely
(C) the fuel is wet
(D) the fuel is burning completely
- Q.4** A covalent bond is formed by
(A) complete transfer of electrons
(B) one sided sharing of electron
(C) mutual sharing of electron
(D) all of the three above.
- Q.5** Which of the following compounds does not contain a multiple bond?
(A) Ethane (B) Ethene
(C) Ethyne (D) Benzene
- Q.6** Which of the following is not a saturated hydrocarbon?
(A) Cyclohexane (B) Benzene
(C) Butane (D) Isobutane
- Q.7** Benzene with molecular formula, C_6H_6 , has
(A) 6 single bonds and 6 double bonds
(B) 12 single bonds and 3 double bonds
(C) 18 single bonds only
(D) 12 double bonds only
- Q.8** The functional group in methanol and methanal respectively are :
(A) $-OH$, $-CHO$ (B) $-CHO$, $-OH$
(C) $-OH$, $-COOH$ (D) $-CHO$, $-COOH$
- Q.9** Which of the following is not an allotropic form of carbon?
(A) Coal (B) Fullerene
(C) Diamond (D) Graphite
- Q.10** Graphite is a soft lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite
(A) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interplate bonds
(B) is a non-crystalline substance
(C) is an allotropic form of carbon
(D) has only single bonds between carbon atoms

- Q.11** Which of the following represent the correct order of unsaturation?
(A) Alkanes, alkenes, alkynes
(B) Alkanes, alkynes, alkenes
(C) Alkenes, alkynes, alkenes
(D) Alkynes, alkanes, alkenes
- Q.12** The general formula of alcohol is
(A) $C_nH_{2n+2}OH$ (B) $C_nH_{2n+1}OH$
(C) $C_nH_{2n-1}OH$ (D) $C_nH_{2n+4}OH$
- Q.13** Wine contains
(A) CH_3OH (B) C_6H_5OH
(C) C_2H_5OH (D) CH_3COOH
- Q.14** The acid present in vinegar is
(A) CH_3COOH
(B) $HCOOH$
(C) CH_3CH_2COOH
(D) $CH_3CH_2CH_2COOH$
- Q.15** The reaction $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$ suggests that ethanol is
(A) Acidic in nature (B) Basic in nature
(C) Amphoteric (D) Neutral
- Q.16** Which of the following substance is added to denature ethanol?
(A) Methanol (B) Benzene
(C) Copper nitrate (D) Poison
- Q.17** Which of the following substances cannot be used to distinguish ethanol from ethanoic acid?
(A) Na metal
(B) $NaHCO_3$
(C) hot alkaline $KMnO_4$ solution
(D) hot acidified $K_2Cr_2O_7$ solution
- Q.18** An example of soap is
(A) CH_3COONa (B) CH_3ONa
(C) $C_{17}H_{35}COONa$ (D) $C_{17}H_{35}COOC_2H_5$
- Q.19** Detergents are sodium or potassium salts of long chain
(A) aldehydes (B) ketones
(C) carboxylic acids (D) sulphonic acids
- Q.20** Which of the following salts when dissolved in water produce hard water?
(A) Calcium sulphate
(B) Magnesium bicarbonate
(C) Calcium chloride
(D) Any of the above
- Q.21** Which of the following represents Lewis structure of N_2 molecule?
(A) $\times N \equiv N \times$ (B) $\times N \equiv N \times$
(C) $\times N - N \times$ (D) $\times N = N \times$
- Q.22** Which of the following has the shortest carbon-carbon bond length?
(A) C_2H_2
(B) C_2H_4
(C) C_2H_6
(D) All have the same bond length



Q.23 Which of the following has the weakest carbon-carbon bond strength?

- (A) C_2H_2
- (B) C_2H_4
- (C) C_2H_6
- (D) All have the same bond length

Q.24 The hydrocarbon with the general formula C_nH_{2n+2} is an -

- (A) Alkane
- (B) Alkene
- (C) Alkyne
- (D) unsaturated compounds

Q.25 Which of the following is an alkyne ?

- (A) C_6H_6
- (B) C_6H_{12}
- (C) C_6H_{10}
- (D) C_6H_{14}

B. FILL IN THE BLANKS TYPE QUESTION

Q.1 The ability of carbon atom to link with other carbon atom is known as

Q.2 The hydrocarbons containing only single bonds are known as

Q.3 Aliphatic hydrocarbons have been classified as alkanes, and alkynes.

Q.4 hydrocarbons undergo addition reaction.

Q.5 Isomers have same molecular formula but different formula.

Q.6 Hydrocarbons are insoluble in

Q.7 The next homologue of ethene is

Q.8 During the formation of hydrogen molecule from its atoms, energy is

Q.9 Bond between hydrogen and chlorine in HCl is

Q.10 $CH_2 = CH_2 + H_2 \xrightarrow{?} CH_3 - CH_3$

Q.11 The general formula of the homologous series of alcohols is

Q.12 The functional group present in ethanol is

Q.13 When ethanol is warmed with alkaline potassium permanganate, the product formed is

Q.14 When a piece of sodium metal is added to ethanol, the gas formed with effervescence is

Q.15 Ethene and ethyne are examples of hydrocarbons.

Q.16 Thegroup in a soap molecule is hydrophilic.

C. TRUE & FALSE

Q.1 Methane belongs to the homologous series of alkanes.

Q.2 The compound having the molecular formula C_4H_{10} does not show isomerism.

Q.3 The methane molecule has a pyramidal shape.

Q.4 Methane undergoes substitution reaction.

Q.5 The consumption of ethanol increases the activity of the body.

Q.6 Ethanoic acid is used in the manufacture of textiles.

Q.7 Alkenes as well as alkynes decolourise bromine water.

Q.8 Vanaspati ghee is obtained by the hydrogenation of vegetable oil.

Q.9 Alkanes undergo substitution reactions.

Q.10 Alkenes and alkynes are unsaturated compounds.

Q.11 Ethanol is oxidised by alkaline $KMnO_4$ to oxalic acid.

Q.12 Detergents give scum with hard water.

Q.13 The polar end in soap is called hydrophilic end.

Q.14 Methanol is safe to be used for drinking purpose.

Q.15 The reaction of ethanol with conc. H_2SO_4 gives ethane.

Q.16 Carboxylic acids react with alcohols to form esters.

D. VERY SHORT ANSWER TYPE QUESTIONS

Q.1 Name an allotrope of carbon which has 60 carbon atoms.

Q.2 What is combustion?

Q.3 What is the nature of substances that produce a flame?

Q.4 The molecular formula of a compound is C_2H_6O . Name its homologous series.

Q.5 What type of reactions are given by alkanes?

Q.6 What is the composition of natural gas used for cooking?

Q.7 Name an allotrope of carbon which contains both single and double bonds between carbon atoms.

Q.8 Write the name and molecular formula of alcohol derived from butane.

Q.9 What is rectified spirit?

Q.10 Give the name and structural formula of one homologue of $HCOOH$.

Q.11 Why does hard water not produce foam with soap easily?

Q.12 Name the hydrophobic and hydrophilic ends of a soap.

Q.13 An organic compound burns with a sooty flame. Is it saturated or unsaturated compound?



E. SHORT ANSWER TYPE QUESTION

- Q.1** Name any four substance obtained from organic compounds which are used in our daily life.
- Q.2** Hydrogen and chlorine react to form hydrochloric acid. Will they form an ionic or covalent bond?
- Q.3** How many electrons a carbon atom shares with other carbon atom in the formation of acetylene molecule?
- Q.4** Give examples of covalent compounds which contain :
(a) one unshared pair of electron
(b) two unshared pairs of electrons.
- Q.6** What is meant by homologous series? Give its three important characteristics.
- Q.7** Name the functional group present in :
(i) $\text{CH}_3\text{CH}_2\text{OH}$, and (ii) HCOOH .
- Q.8** The molecular formula of a hydrocarbon is C_5H_{10} . Name its homologous series.
- Q.9** Write structural formulae of the following compounds.
(i) Ethyl alcohol (ii) Acetaldehyde
(iii) Propionic acid (iv) Butanone
- Q.10** What is the IUPAC name of fourth member of alcohol series? Draw its two structural isomers.
- Q.11** Write the general formulae of the following homologous series.
(i) Aldehydes (ii) Ketones
(iii) Alkyne
- Q.12** How do alcohols differ structurally from alkanes?
- Q.13** Give the common and IUPAC names of the following alcohols :
(i) CH_3OH (ii) $\text{CH}_3\text{CH}_2\text{OH}$
(iii) $\text{CH}_3\text{CHOHCH}_3$
- Q.14** Identify the functional group in $\text{CH}_3\text{CH}_2\text{OH}$. Give IUPAC name of the compound.
- Q.15** Ethanol can be oxidised to ethanoic acid. Write the equation involved in the reaction.
- Q.16** Name the oxidising agent which can oxidise:
(i) Ethanol to ethanal
(ii) Ethanol to ethanoic acid.

F. LONG ANSWER TYPE QUESTION

- Q.1** What is covalent bond ? Draw electron dot structure for the following :
(i) Methane (ii) Carbon dioxide
(iii) Ammonia (iv) Water
- Q.2** Explain the following reaction with one example each :
(i) Substitution reactions
(ii) Addition reactions
(iii) Combustion reactions
(iv) Oxidation reactions
- Q.3** (i) What are alcohols ? What is functional group?
(ii) Write names and formulae of first four members of alcohols family.
(iii) How does the second member of alcohol family react with
(a) Sodium metal (b) Ethanoic acid

ANSWER KEY
A. MULTIPLE CHOICE QUESTION

- | | | | |
|--------------|--------------|--------------|--------------|
| 1. B | 2. C | 3. B | 4. C |
| 5. A | 6. B | 7. B | 8. A |
| 9. A | 10. A | 11. A | 12. B |
| 13. C | 14. A | 15. A | 16. A |
| 17. A | 18. C | 19. D | 20. D |
| 21. A | 22. A | 23. C | 24. A |
| 25. C | | | |

B. FILL IN THE BLANKS

- | | |
|---|-------------------------------------|
| 1. Catenation | |
| 2. Alkanes/saturated hydrocarbon | |
| 3. Alkenes | 4. Unsaturated |
| 5. Structural | 6. Water |
| 7. Propene | 8. Released |
| 9. Covalent | 10. Ni catalyst |
| 11. $\text{C}_n\text{H}_{2n+1}\text{OH}$. | 12. Hydroxy |
| 13. Ethanoic acid | 14. Hydrogen |
| 15. Unsaturated | 16. Polar / COONa^+ |

C. TRUE OR FALSE

- | | | | |
|--------------|--------------|--------------|--------------|
| 1. T | 2. F | 3. F | 4. T |
| 5. F | 6. T | 7. T | 8. T |
| 9. T | 10. T | 11. F | 12. F |
| 13. T | 14. F | 15. F | 16. T |



EXERCISE – III
OLYMPIAD QUESTIONS

- Q.1** Which of the following is an example of fossil fuel?
 (A) coal gas (B) coke
 (C) natural gas (D) producer gas
- Q.2** Most of the fuels are:
 (A) carbon compounds with sulphur
 (B) nitrogen compounds with carbon
 (C) carbon compounds with hydrogen
 (D) none of these
- Q.3** Destructive distillation of coal leads to the formation of
 (A) wood (B) kerosene
 (C) ammoniacal liquor (D) charcoal
- Q.4** When steam is passed over hot coke, it produces
 (A) producer gas (B) synthesis gas
 (C) tear gas (D) coal gas
- Q.5** Producer gas is a mixture of
 (A) carbon monoxide and nitrogen gas
 (B) carbon monoxide and hydrogen gas
 (C) carbon monoxide and water vapour
 (D) carbon monoxide and nitrous oxide
- Q.6** Which of the following is not obtained on fractional distillation of petroleum?
 (A) Paraffin wax (B) Asphalt
 (C) Coal gas (D) Petroleum gas
- Q.7** The property of an atom to form a bond with itself is known as:
 (A) isomerism (B) catenation
 (C) allotropy (D) none of these
- Q.8** In the hydrocarbon $\text{HC} \equiv \text{C} - \text{H}$, the covalency of carbon is:
 (A) one (B) two
 (C) three (D) four
- Q.9** Which of the following are isomers?
 (A) ethane and propane
 (B) ethane and ethene
 (C) ethene and ethyne
 (D) butane and isobutane
- Q.10** A hydrocarbon is:
 (A) a compound containing carbon, hydrogen and oxygen
 (B) is sodium hydrogen carbonate
 (C) a compound containing carbon and hydrogen only
 (D) a derivative of benzene
- Q.11** The formula of ethyne is:
 (A) C_2H_2 (B) C_6H_6
 (C) C_2H_4 (D) C_2H_6
- Q.12** The formula of tetrachloro methane is:
 (A) CClH_3 (B) CCl_2
 (C) CHCl_3 (D) CCl_4
- Q.13** An unsaturated hydrocarbon
 (A) contains six carbon atoms
 (B) contains fewer hydrogen atoms that is needed for carbon to have its usual valency of four
 (C) contains excess hydrogen
 (D) contains a chain of carbon atom
- Q.14** Water gas consists of:
 (A) water vapour and coal dust
 (B) a mixture of carbon monoxide and hydrogen
 (C) a mixture of carbon monoxide and nitrogen
 (D) water vapour and methane
- Q.15** The reaction of one mol of bromine with ethyne yields:
 (A) $\text{BrCH}_2 - \text{CH}_2\text{Br}$ (B) $\text{BrCH} = \text{CHBr}$
 (C) $\text{Br}_2\text{CH} - \text{CHBr}_2$ (D) $\text{CH}_3 - \text{CH}_2\text{Br}$
- Q.16** Which of the following gas is known as illuminating gas?
 (A) Ethane (B) Ethene
 (C) Ethyne (D) Propane
- Q.17** The gas used in the welding and cutting of metals is:
 (A) ethane (B) ethene
 (C) ethyne (D) propane
- Q.18** Which of the following does not give a positive test with alkaline solution of potassium permanganate?
 (A) $\text{C}_{10}\text{H}_{22}$ (B) C_6H_{12}
 (C) $\text{C}_{10}\text{H}_{18}$ (D) $\text{C}_{10}\text{H}_{20}$
- Q.19** The process by which smaller molecules combine to give a molecule with a higher molecular weight is known as:
 (A) condensation (B) polymerisation
 (C) catenation (D) isomerisation

ANSWER KEY

- | | | | | | | | |
|------------|---|------------|---|------------|---|------------|---|
| 1. | C | 2. | C | 3. | A | 4. | B |
| 5. | A | 6. | C | 7. | B | 8. | D |
| 9. | D | 10. | C | 11. | A | 12. | D |
| 13. | B | 14. | B | 15. | B | 16. | C |
| 17. | C | 18. | A | 19. | B | | |



EXERCISE – IV
NTSE / ISO / IJO QUESTIONS

1. Which of the following is a crystalline form of carbon?
(A) Charcoal (B) Coal
(C) Graphite (D) Lamp black
2. Which of the following is the purest form of carbon?
(A) Charcoal (B) Coal
(C) Diamond (D) Graphite
3. Each carbon atom in diamond is attached with four carbon atoms through four covalent bonds. This is why diamond is :
(A) A good conductor of heat
(B) A good conductor of electricity
(C) Purest form of carbon
(D) Such a hard substance
4. Which of the following statements regarding graphite is not correct?
(A) Graphite is a black and soft crystalline substance
(B) Graphite is manufactured by heating coke at 3000°C
(C) Graphite is a bad conductor of heat and electricity
(D) Graphite possesses a metallic lusture and soapy touch
5. Graphite has a much lower density than its allotrope diamond. It is because :
(A) Graphite has a characteristic greasy feel and metallic lusture
(B) Graphite has a more open structure than diamond
(C) Graphite is a good conductor of electricity while diamond is not
(D) Graphite is a good conductor of heat while diamond is not
6. Diamond and graphite resemble each other chemically because they :
(A) Are both allotropes of carbon and contains atoms of the same kind
(B) Have atoms arranged in the same way
(C) Are good conductors of heat and electricity
(D) Have high melting points
7. Animal charcoal, wood charcoal, lamp black and sugar charcoal are amorphours forms of carbon. Which of the following contains calcium phosphate?
(A) Animal charcoal (B) Wood charcoal
(C) Lamp black (D) Sugar charcoal
8. A correct statement about charcoal, diamond, graphite and methane is that they all :
(A) Are allotropes of carbon
(B) Are soluble in water
(C) Form CO₂ on combustion
(D) Have high melting points
9. The decolorising action of bone charcoal is due to its capacity to :
(A) Adsorb (B) Float
(C) Oxidize (D) Reduce
10. Which of the following statements is not correct?
(A) Graphite is much less dense than diamond
(B) Graphite is black and soft
(C) Graphite has low melting point
(D) Graphite feels smooth and slippery
11. Which of the following statements is not correct regarding graphite crystal?
(A) The carbon atoms are arranged in planar layers in the graphite crystals
(B) Within each layer of graphite, each carbon atom is bonded to three other carbon atoms by covalent single bonds
(C) The atoms in each layer are not tightly bonded together
(D) The binding force between layers is weak allowing the layers to slip over each other
12. Which of the following statements correct?
(A) Graphite is a bad conductor of electricity
(B) Dry graphite in a vaccum is not slippery
(C) The adsorption of substance increases the friction as the layer slide past each other
(D) The graphite does not possess metallic properties
13. Which of the following statements regarding diamond is not correct?
(A) Diamond is clear and colourless substance
(B) Diamond is the hardest substance known



14. Which of the following statements regarding diamond is not correct?
 (A) Diamond does not refract light
 (B) When proper cut and polished, a diamond reflects light in an array of many colours
 (C) Diamond is less stable than graphite
 (D) Impure sample of diamond is often black and are used in abrasives
15. Which of the following statements is not correct?
 (A) Diamond can be made in a laboratory
 (B) Gem-quality diamonds can be made in a laboratory
 (C) Titanium dioxide and strontium titanate are the examples of diamond-like synthetic gems
 (D) Graphite is the black ingredient in pencils
16. Organic compounds will always contain :
 (A) Carbon (B) Hydrogen
 (C) Nitrogen (D) Sulphur
17. The molecular shape of methane is :
 (A) Octahedral (B) Planar
 (C) Pyramidal (D) Tetrahedral
18. Methane, ethane and propane are said to form a homologous series because all are -
 (A) Hydrocarbons
 (B) Saturated compounds
 (C) Aliphatic compounds
 (D) Differ from each other by a CH_2 group
19. The bond angle in methane molecule is :
 (A) 90° (B) $109^\circ, 28^\circ$
 (C) 120° (D) 180°
20. Organic compounds are generally :
 (A) Covalent in nature
 (B) Ionic in nature
 (C) Insoluble in organic solvents
 (D) Soluble in water
21. Which of the following is not true for organic compounds?
 (A) They form homologous series
 (B) They show isomerism
 (C) They are mostly obtained from vegetable or animal kingdom
 (D) They are usually soluble in water but insoluble in organic solvents
22. The isomers have the same
 (A) Chemical properties
 (B) Molecular formula
 (C) Physical properties
 (D) Structural formula
23. Which of the following pairs is an example of chain isomers?
 (A) $\text{CH}_3\text{CH}_2\text{OH}$ and CH_3OCH_3
 (B) $\text{CH}_3\text{CH}_2\text{CHO}$ and CH_3COCH_3
 (C) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
 (D) $\text{Cl}_2\text{C} = \text{CH}_2$ and $\text{ClHC} = \text{CHCl}$
24. The number of chain isomers in pentane is :
 (A) 1 (B) 2
 (C) 3 (D) 4
25. The number of chain isomers in hexane is :
 (A) 1 (B) 3
 (C) 5 (D) 7
26. Carbon forms a large number of compounds because it :
 (A) Has great chemical affinity
 (B) Shows variable valency
 (C) Forms many isotopes
 (D) Has property of catenation
27. When methane is burnt in an excess of air, the products of combustion are :
 (A) C and H_2O (B) CO and H_2O
 (C) CO_2 and H_2 (D) CO_2 and H_2O
28. The general formula of alkane series is :
 (A) $\text{C}_n\text{H}_{2n-2}$ (B) C_nH_{2n}
 (C) $\text{C}_n\text{H}_{2n+2}$ (D) $\text{C}_n\text{H}_{2n+4}$
29. Which of the following pairs of skelton in alkanes constitutes isomers?
 (A) $\text{C} - \text{C} - \text{C} - \text{C} - \text{C}$ and $\begin{array}{c} \text{C} \\ | \\ \text{C} - \text{C} - \text{C} \\ | \\ \text{C} \end{array}$
 (B) $\begin{array}{c} \diagup \diagdown \\ \text{C} \end{array} - \text{C} - \text{C}$ and $\begin{array}{c} \text{C} - \text{C} - \text{C} - \text{C} \\ | \\ \text{C} \end{array}$
 (C) $\text{C} - \text{C} - \text{C} - \text{C}$ and $\begin{array}{c} \text{C} - \text{C} - \text{C} \\ | \\ \text{C} \end{array}$
 (D) $\text{C} - \text{C} - \text{C} - \text{C}$ and $\begin{array}{c} \text{C} - \text{C} - \text{C} \\ | \\ \text{C} \end{array}$
30. Which of the following gases is produced on heating 2 grams each of sodium acetate and soda lime in a hard glass boiling tube?



31. Which of the following gases is called 'marsh gas'?
- (A) H_2 (B) CO
(C) CO_2 (D) CH_4
32. The next higher homologue of propane is :
- (A) C_2H_6 (B) CH_4
(C) C_2H_4 (D) C_2H_2
33. The IUPAC name of $CH_3CH_2CH_2CH_3$ is :
- (A) Methylpropane (B) Ethylethane
(C) Butane
(D) 1, 2-dimethylethane
34. The IUPAC name of $CH_3CHCH_2CH_3$ is :
- $\begin{array}{c} CH_2CH_3 \\ | \\ CH_3CHCH_2CH_3 \end{array}$
- (A) 1, 1-methylethylpropane
(B) 2-ethylbutane
(C) 1-methyl-1-ethylpropane
(D) 3-methylpentane
35. Which of the following gases is liberated when a mixture of sodium propanoate and soda lime is heated?
- (A) CH_4 (B) CH_3CH_3
(C) CO_2 (D) $CH_3CH_2CH_3$
36. The final product of chlorination of methane in the sun light is :
- (A) CH_3Cl (B) CH_2Cl
(C) $CHCl_3$ (D) CCl_4
37. Which of the following types of reactions is characteristic of compounds having a double bond?
- (A) Addition (B) Condensation
(C) Isomerization (D) Substitution
38. Alkenes are characterized by :
- (A) C – C bonds (B) C = C bonds
(C) C \equiv C bonds (D) Cyclic structure
39. Which of the following gases decolorises bromine water?
- (A) CH_4 (B) C_2H_2
(C) C_2H_6 (D) C_3H_8
40. Which of the following gases decolorises alkaline $KMnO_4$ solution?
- (A) CH_4 (B) C_2H_2
(C) C_2H_6 (D) C_3H_8
41. The IUPAC name of $CH_3CH_2CH = CH_2$ is :
- (A) Butene (B) Isobutene
42. The IUPAC name of $CH = CHCH_3$ is :
- $\begin{array}{c} CH_3 \\ | \\ CH = CHCH_3 \end{array}$
- (A) Butene (B) Isobutene
(C) But-2-ene (D) 3-methylprop-2-ene
43. The treatment of ethene with alkaline solution of $KMnO_4$ produces :
- (A) CH_3CH_2OH (B) $HOCH_2CH_2OH$
(C) CH_3CHO (D) CH_3COCH_3
44. The IUPAC name of acetylene is :
- (A) Ethane (B) Ethene
(C) Ethylene (D) Ethyne
45. In acetylene, the two carbon atoms are joined by a :
- (A) Single bond (B) Double bond
(C) Triple bond (D) Ionic bond
46. The general formula of alkyne is :
- (A) C_nH_n (B) C_nH_{2n-2}
(C) C_nH_{2n} (D) C_nH_{2n+2}
47. Alkynes have in their molecule :
- (A) Four hydrogen atoms more than in a molecule of corresponding alkane
(B) Two hydrogen atoms more than in a molecule of corresponding alkane
(C) Two hydrogen atoms less than in a molecule of corresponding alkane
(D) Two hydrogen atoms less than in a molecule of corresponding alkene
48. A compound with the molecular formula C_2H_2 must contain :
- (A) All single bonds
(B) One double bond
(C) One triple bond
(D) None of the above
49. When ethyne is burnt in excess of air, the products of combustion are :
- (A) C and H_2O (B) CO and H_2O
(C) CO_2 and H_2 (D) CO_2 and H_2O
50. Which gas is produced when water reacts with calcium carbide?
- (A) CH_4 (B) C_2H_2
(C) C_2H_4 (D) C_3H_8
51. Which of the following gases burns with a sooty flame?
- (A) CH_4 (B) C_2H_2



- (C) C_2H_6 (D) $C_3H_8 < C_2H_6$
52. The IUPAC name of $\begin{array}{c} CH_2CH_2C \equiv CH \\ | \\ CH_3 \end{array}$ is :
 (A) Pentyne (B) 4-methylbutyne
 (C) 1-methylbut-3-yne
 (D) Propylethyne
53. Which of the following gases is produced when cold water is added on calcium carbide?
 (A) C_2H_2 (B) C_2H_4
 (C) C_2H_6 (D) C_3H_8
54. Across a triple bond, the number of molecules of Br_2 that can be added is :
 (A) One (B) Two
 (C) Three (D) Zero
55. When acetylene is passed over heated iron tube, the product obtained is :
 (A) C_2H_2 (B) C_4H_4
 (C) C_6H_6 (D) C_8H_8
56. The treatment of acetylene with alkaline $KMnO_4$ solution produces :
 (A) CH_3CHO (B) $HOCH_2CH_2OH$
 (C) $\begin{array}{c} CH_2OH \\ | \\ COOH \end{array}$ (D) $\begin{array}{c} COOH \\ | \\ COOH \end{array}$
57. The gas used in the flame produced for welding metals is :
 (A) Methane (B) Methene
 (C) Methyne (D) Ethyne
58. The amount of oxygen used in the combustion of 1 mol of ethene is :
 (A) 1 mol (B) 2 mol
 (C) 2.5 mol (D) 3 mol
59. The amount of oxygen used in the combustion of 1 mol of ethene is :
 (A) 1 mol (B) 2 mol
 (C) 2.5 mol (D) 3 mol
60. The treatment of ethanol with concentrated sulphuric acid produces :
 (A) Ethane (B) Ethene
 (C) Ethyne (D) None of these
61. The general formula of alcohols is :
 (A) $C_nH_{2n}OH$ (B) $C_nH_{2n+1}OH$
 (C) $C_nH_{2n+2}OH$ (D) $C_nH_{2n-1}OH$
62. The IUPAC name of $\begin{array}{c} CH_2CH_2OH \\ | \\ CH_3 \end{array}$ is :
 (A) 3-methylethanol (B) Propanol
 (C) 1-hydroxypropane (D) 1-hydroxy-2-ethane
63. The number of oxygen molecules used in the combustion of 1 molecule of ethanol is :
 (A) 1 (B) 2
 (C) 3 (D) 4
64. The final product obtained in the oxidation of ethanol by acidic potassium dichromate is :
 (A) C_2H_5OH (B) CH_3CHO
 (C) CH_3COOH (D) $\begin{array}{c} COOH \\ | \\ COOH \end{array}$
65. The distillation of a mixture of ethanol and bleaching powder produces :
 (A) Ethanal (B) Chloral
 (C) Chloroform (D) Carbon tetrachloride
66. The treatment of ethanol with alkaline iodine solution produces :
 (A) Ethanal (B) Iodorm
 (C) Carbon tetraiodide (D) Diiodomethane
67. Which of the following gases gives a reddish brown precipitate with ammoniacal cuprous chloride solution?
 (A) CH_4 (B) C_2H_2
 (C) C_2H_4 (D) C_2H_5OH vapours
68. 'Drinking alcohol' is very harmful and it ruins the health. 'Drinking alcohol' stands for :
 (A) Drinking methyl alcohol
 (B) Drinking ethyl alcohol
 (C) Drinking propyl alcohol
 (D) Drinking isopropyl alcohol
69. Sodium is used for testing an :
 (A) Alcohol (B) Aldehyde
 (C) Alkane (D) Alkene
70. An alcohol produces a characteristic colour when treated with ceric ammonium nitrate solution. The colour is :
 (A) Blue (B) Green
 (C) Yellow (D) Red
71. The general formula of a carboxylic acid is :
 (A) $C_nH_{2n-1}COOH$ (B) $C_nH_{2n}COOH$
 (C) $C_nH_{2n+1}COOH$ (D) $C_nH_{2n+2}COOH$
72. The IUPAC name of $\begin{array}{c} CH_2COOH \\ | \\ CH_3 \end{array}$ is :



- (A) Propionic acid (B) Propanoic acid
(C) 1-methylethanoic acid
(D) 2-methylethanoic acid
- 73.** The treatment of acetic acid with lithium aluminium hydride produces :
(A) Methanol (B) Ethanol (C) Ethanal (D) Methanal
- 74.** The treatment of CH_3COOH with $\text{C}_2\text{H}_5\text{OH}$ in the presence of concentrated sulphuric acid produces :
(A) $\text{CH}_3\text{COOCH}_3$ (B) $\text{CH}_3\text{COOC}_2\text{H}_5$ (C) $\text{C}_2\text{H}_5\text{COOCH}_3$ (D) $\text{C}_2\text{H}_5\text{COOC}_2\text{H}_5$
- 75.** Which of the following compounds gives effervescence with sodium bicarbonate?
(A) HCHO (B) CH_3CHO (C) CH_3COOH (D) $\text{CH}_3\text{COOC}_2\text{H}_5$
- 76.** Which of the compounds is an organic acid?
(A) $\text{H}-\text{C}(=\text{O})-\text{H}$ (B) CH_3COCH_3
(C) HCOOH (D) $\text{CH}_3\text{CHOHCH}_3$
- 77.** Vinegar is a dilute solution of
(A) Acetic acid (B) Propanoic acid
(C) Butanoic acid (D) Formaldehyde
- 78.** The general formula of an aldehyde is :
(A) $\text{C}_n\text{H}_{2n}\text{CHO}$ (B) $\text{C}_n\text{H}_{2n-1}\text{CHO}$
(C) $\text{C}_n\text{H}_{2n+2}\text{CHO}$ (D) $\text{C}_n\text{H}_{2n}\text{O}$
- 79.** Formaline is :
(A) 40% aqueous solution of formaldehyde
(B) 20% aqueous solution of formaldehyde
(C) 40% solution of formaldehyde in ethanol
(D) 40% solution of formaldehyde in chloroform
- 80.** The starting substances used in bakelite resin is :
(A) $\text{HCHO} + \text{C}_6\text{H}_5\text{OH}$
(B) $\text{CH}_3\text{CHO} + \text{C}_6\text{H}_5\text{CHO}$
(C) $\text{HCHO} + \text{C}_6\text{H}_5\text{CHO}$
(D) $\text{HCHO} + \text{CH}_3\text{CHO}$
- 81.** Which of the following compounds deposits shining silver with Tollens reagent (ammoniacal silver nitrate solution)?
(A) CH_3CHO (B) CH_3OH
(C) CH_3COOH (D) $\text{CH}_3\text{CH}_2\text{OH}$
- 82.** Which of the following is an aldehydic functional group?
(A) $-\text{C}\equiv\text{C}-$ (B) $-\text{C}(=\text{O})-\text{H}$
(C) $-\text{C}(=\text{O})-\text{OH}$ (D) OH
- 83.** Which of the following substances will form red precipitate with Fehling's solution?
(A) $\text{CH}_3\text{CH}_2\text{OH}$ (B) CH_3COCH_3
(C) CH_3COOH (D) CH_3CHO
- 84.** Tollens reagent is :
(A) Ammoniacal solution of copper sulphate
(B) Ammoniacal solution of silver nitrate
(C) Ammoniacal solution of ferrous sulphate
(D) Ammoniacal solution of sodium chloride
- 85.** The IUPAC name of $\text{CH}_3\text{CH}_2\text{CHO}$ is :
(A) Propanal (B) Propanol
(C) Propanoic acid (D) 2-methylethanal
- 86.** The oxidation of $\text{CH}_3\text{CH}_2\text{CHO}$ produces :
(A) CH_3COOH (B) $\text{CH}_3\text{CH}_2\text{COOH}$
(C) CH_3COCH_3 (D) $\text{CH}_2(\text{COOH})_2$
- 87.** Which of the following compounds is phenol?
(A) $\text{C}_6\text{H}_5\text{COOH}$ (B) $\text{C}_6\text{H}_5\text{CHO}$
(C) $\text{C}_6\text{H}_5\text{OH}$ (D) $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$
- 88.** Identify the 'product' in the reaction $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \xrightarrow{\text{conc. H}_2\text{SO}_4}$ 'product' + H_2O
(A) Alcohol (B) Aldehyde
(C) Ketone (D) Ester
- 89.** Identify the 'product' in the reaction $\text{HCHO} + \text{Ag}_2\text{O} \longrightarrow$ 'product' + 2Ag
(A) Alcohol (B) Acid
(C) Ether (D) Ester
- 90.** Identify the product in the reaction $\text{HCHO} + 2\text{CuO} \longrightarrow$ 'product' + Cu_2O :
(A) Alcohol (B) Acid
(C) Ether (D) Ester
- 91.** Identify the product in the reaction $\text{CH}\equiv\text{CH}$



CARBON & ITS COMPOUNDS

92. $+ Br_2 \longrightarrow CHBr = CHBr \xrightarrow{Br_2}$ 'product' :
 (A) CH_2BrCH_2Br (B) $CHBr_2CHBr_2$
 (C) CH_3CHBr_2 (D) CH_3CBr_3
93. Identify the 'product' in the reaction
 $CH_3CH_2OH \xrightarrow{K_2Cr_2O_7 / H_2SO_4}$ 'product' + H_2O :
 (A) Acid (B) Aldehyde
 (C) Ketone (D) Ester
94. Identify the 'product' in the reaction
 $CH_3CH_2COONa \xrightarrow{\text{soda lime}}$ 'product' + Na_2CO_3
 (A) Alkane (B) Alkene
 (C) Alkyne (D) Acid
95. Identify the 'product' in the reaction $CH_3COOH \xrightarrow{LiAlH_4}$ 'product' + H_2O :
 (A) Aldehyde (B) Alcohol
 (C) Ketone (D) Acid
96. The fruity smell is of a/an :
 (A) Aldehyde (B) Ketone
 (C) Alcohol (D) Ester
97. The 'product' in the reaction $CH_3CH_2OH \xrightarrow[350^\circ C]{Al_2O_3}$ 'product' + H_2O is :
 (A) Alkane (B) Alkene
 (C) Alkyne (D) None of these
98. The fermentation reactions are carried out in temperature range of :
 (A) 20–30 °C (B) 30–40 °C
 (C) 40–50 °C (D) 50–60 °C
99. The 'product' of the reaction $CH_2 = CH_2 \xrightarrow{KMnO_4, [O]}$ 'product' is :
 (A) CH_3COOH (B) $HOCH_2CH_2OH$
 (C) $\begin{array}{c} \text{COOH} \\ | \\ \text{COOH} \end{array}$ (D) None of these
100. The product of $CH_2 = CH_2 + Cl_2 \longrightarrow$ 'product' is :
 (A) CH_3CHCl_2 (B) $CH_2 = CHCl$
 (C) $CH_2 = CCl_2$ (D) $ClCH_2CH_2Cl$
101. Octane number is zero for
 (A) n-heptane
 (B) 2, 3, 3-trimethylpentane
 (C) 2, 2, 4-trimethylpentane
 (D) n-octane
102. Octane number is 100 for
 (A) π -pentane
 (B) 2, 3, 3-trimethylpentane
 (C) 2, 2, 4-trimethylpentane
 (D) n-octane

CARBON & ITS COMPOUNDS							ANSWER KEY						EXERCISE							
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	C	C	D	C	B	A	A	C	A	C	C	B	C	A	B	A	D	D	B	A
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	D	B	C	C	C	D	D	C	D	D	B	C	C	D	B	D	A	B	B	B
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	A	C	B	D	C	B	D	C	D	B	B	A	A	B	C	D	D	C	D	B
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	B	B	C	C	C	B	B	B	A	D	C	B	B	B	C	C	A	D	A	A
Que.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	A	B	D	B	A	B	C	D	B	B	B	A	A	B	D	B	B	A	B	D
Que.	101	102																		
Ans.	A	C																		

